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### CHARTS.



† In marine separate.

### CORRECTION.

REVIEW, January, 1923:

**Page 19, first column, third paragraph should be amended to read: "Table 2 contains the monthly discharge measurements as made by the water resources branch of the United States Geological Survey from 1909–1914, inclusive, and by the State engineer of New Mexico from 1915–1922, inclusive, near Buckman, N. Mex."**

# MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

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## THE WIND FACTOR IN FLIGHT: AN ANALYSIS OF ONE YEAR'S RECORD OF THE AIR MAIL.[1]

By Willis Ray Gregg, Meteorologist, and Lieut. J. Parker Van Zandt, United States Air Service.

[Washington, D. C., Apr. 27, 1923.]

SYNOPSIS.

From an analysis of one year's records of the Air Mail Service between New York and San Francisco it has been found that at the average altitude of flight, about 1,500 feet above the ground, allowance must be made for a wind of 7 miles per hour from the west. In other words westward flights will, on the average, be made at a speed of 14 miles per hour less than will eastward flights. A more detailed study of the New York to Chicago part of the route gives almost exactly the same wind factor as for the entire transcontinental route. This value of the wind factor has been verified by an examination of 9,267 free-air observations with kites and pilot balloons, and the agreement is remarkably close. The importance of this agreement lies in the fact that, in fixing flight schedules in other regions or at other altitudes, dependence can be placed upon *either* method in case only one is available.

From a further study of the data, schedules that can be guaranteed 90 per cent of the time have been determined for aircraft of any cruising speed between 50 and 150 miles per hour. In making up these schedules allowance has been made for head winds of 36 miles per hour or more in westward flight and 20 miles per hour or more in eastward flight, these being the wind speeds that are shown by kite and balloon records to occur 5 per cent of the time. When they do occur, the flights will be somewhat delayed, but nevertheless completed. During the remaining 5 per cent of the time flights are likely to fail altogether or be seriously delayed because of exceptionally unfavorable weather, such as severe rain or snow storms, poor visibility, etc.

Finally, a general wind curve has been prepared by means of which various schedules based on other percentage performances, greater or less than 90 per cent and for different lengths of routes, may be determined. With the normal and high cruising speeds known quantities, allowance is made for an adverse wind such that the flight can be made in any desired time. The percentage frequency of this adverse wind is then read from the curve and thus is determined the percentage of the time that the desired schedule can be guaranteed.

### INTRODUCTION.

The Air Mail Service needs no advertising. Its record speaks for itself. Nevertheless, a brief statement, by way of introduction to this paper, is of interest and there follow, therefore, a few excerpts from "Postal Accomplishments of this Administration," recently distributed in mimeographed form by the National Advisory Committee for Aeronautics:

> The Air Mail Service is limited by law to one transcontinental route from New York to San Francisco. This route is 2,680 miles in length, making a round trip of 5,360 miles. This round trip is covered each day, except Sundays and holidays. This necessitates an annual flying schedule of approximately 1,800,000 miles.
>
> The Air Mail Service at present consists of a relay advance of mail from New York across the continent, and vice versa. That is to say, no particular mail is taken for a complete trip across the continent. Certain mail which misses the late night trains out of New York is advanced into Cleveland. Other mail which ordinarily would go into Chicago on a train too late for delivery in the afternoon, is taken from Cleveland into Chicago. This process is repeated in relays across the continent, with the net result that approximately 12,000 pounds of first-class letter mail is advanced each day, a matter of some 3 or 4 hours. It should be noted that this 3 or 4 hour advance may in certain instances mean a real advance of 15 to 18 hours, inasmuch as it may mean the delivery of the mail to consignee late in the evening, which might not otherwise have been delivered until the following morning. * * *
>
> From July 16, 1921, until September 7, 1922, Air-Mail pilots flew approximately 2,000,000 miles without a fatal accident. During the fiscal year ending June 30, 1922, an efficiency of 94.39 was maintained. This means that out of every 100 trips scheduled, 94.39 were finished on schedule time. Our records show that two-thirds of the trips were made in clear weather; one-third were made in foggy, cloudy or stormy weather.
>
> September 16 marked the completion of 10 consecutive weeks of flying the entire transcontinental route with 100 per cent efficiency; that is to say, during these weeks each of the scheduled trips was started and finished exactly on schedule time. The daily route includes the crossing of three mountain ranges, the Alleghenies, the Rockies and the Sierras. * * *
>
> The position of the Post Office Department in the matter of the Air Mail Service is that such information as it is able to develop and such experiments as it is able to follow through to a conclusion are for the benefit of the country at large, and if in this work it is possible to add impetus to the prompt advancement of aeronautics, a notable achievement will have been accomplished for the good of the Nation.

Other parts of this report discuss briefly the types of planes and motors used and plans for undertaking night flying, with a view to maintaining continuous schedule and cutting down the time of the entire trip to about 30 hours. In the present paper we are dealing, not with plans, but with accomplishments, and it can be said, without any exaggeration, that the accomplishments of the Air Mail constitute one of the outstanding developments of the past 2 or 3 years and prove conclusively the practicability of commercial aviation and the wisdom of promoting it with all possible energy and speed. Happily, complete records of flight performance have been kept and there is thus available a large amount of information for use in discussing intelligently the various factors that must be considered in laying out routes, determining schedules, figuring costs, etc. Admittedly, the wind is one of the most important of these factors, and all available data should be used in evaluating it. Such is the purpose of this paper. The records of the Air Mail Service have been used and there have been included some of the results of free-air investigations by means of kites and balloons.

### THE FLIGHTS: THEIR NUMBER AND DISTRIBUTION.

The Air Mail records used in this study are those for the period June 1, 1921, to May 31, 1922, inclusive. These give the actual flying time for the 8 sections into which the entire route has been divided. These sections and

[1] Paper presented at Washington, D. C., before the American Meteorological Society on April 16, 1923, and the American Geophysical Union, Section (c) Meteorology, on April 18, 1923.

their lengths in miles are shown in Figure 1 and are as follows:

| | Miles. |
|---|---|
| New York to Cleveland | 435 |
| Cleveland to Chicago | 335 |
| Chicago to Omaha | 425 |
| Omaha to Cheyenne | 460 |
| Cheyenne to Rock Springs | 240 |
| Rock Springs to Salt Lake | 155 |
| Salt Lake to Reno | 440 |
| Reno to San Francisco | 190 |
| Total | 2,680 |

As stated in the brief report of the Air Mail Service' quoted in part at the beginning of this paper, no flights were attempted on Sundays or holidays. There are thus to be considered 306 instead of 365 days. The actual number of days on which flights were completed along the various sections of the route is given in Table 1, which also contains the average number and the percentage of possible for the entire course. In this and following tables the months are given in regular calendar order, but it is to be understood that January to May refer to 1922, and June to December refer to 1921.

TABLE 1.—*Flights made by Air Mail Service along different sections of the transcontinental route during the period June, 1921, to May, 1922, inclusive.*

| Sections. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of days available, excluding Sundays and holidays. | | | | | | | | | | | | |
| | 25 | 23 | 27 | 25 | 26 | 26 | 25 | 27 | 25 | 26 | 25 | 26 | 306 |
| | Number of flights—Westbound. | | | | | | | | | | | | |
| New York-Cleveland | 20 | 18 | 22 | 23 | 25 | 26 | 25 | 25 | 24 | 24 | 16 | 23 | 271 |
| Cleveland-Chicago | 22 | 22 | 24 | 23 | 26 | 26 | 25 | 27 | 25 | 26 | 20 | 24 | 290 |
| Chicago-Omaha | 24 | 21 | 26 | 25 | 25 | 25 | 25 | 27 | 23 | 26 | 17 | 23 | 287 |
| Omaha-Cheyenne | 24 | 21 | 26 | 22 | 24 | 25 | 23 | 25 | 25 | 25 | 23 | 21 | 284 |
| Cheyenne-Rock Springs | 21 | 17 | 26 | 23 | 25 | 25 | 24 | 25 | 21 | 25 | 22 | 19 | 273 |
| Rock Springs-Salt Lake | 21 | 18 | 25 | 25 | 24 | 25 | 25 | 27 | 24 | 25 | 20 | 21 | 280 |
| Salt Lake-Reno | 17 | 17 | 24 | 23 | 26 | 26 | 25 | 23 | 21 | 26 | 23 | 21 | 272 |
| Reno-San Francisco | 15 | 6 | 20 | 21 | 24 | 22 | 25 | 21 | 22 | 25 | 18 | 16 | 235 |
| Average | 20.5 | 17.5 | 24.1 | 23.1 | 24.9 | 25.0 | 24.6 | 25.0 | 23.1 | 25.2 | 19.9 | 21.0 | 274 |
| Percentage of possible | 82.0 | 76.1 | 89.4 | 92.5 | 95.7 | 96.2 | 98.5 | 92.6 | 92.5 | 97.1 | 79.5 | 80.8 | 89.5 |
| | Number of flights—Eastbound. | | | | | | | | | | | | |
| San Francisco-Reno | 17 | 8 | 18 | 20 | 24 | 25 | 24 | 23 | 22 | 24 | 17 | 17 | 239 |
| Reno-Salt Lake | 18 | 16 | 22 | 23 | 26 | 26 | 24 | 21 | 22 | 26 | 23 | 20 | 267 |
| Salt Lake-Rock Springs | 20 | 18 | 25 | 25 | 24 | 24 | 24 | 27 | 25 | 25 | 23 | 22 | 282 |
| Rock Springs-Cheyenne | 21 | 22 | 27 | 22 | 25 | 24 | 25 | 27 | 25 | 26 | 23 | 23 | 290 |
| Cheyenne-Omaha | 22 | 22 | 24 | 22 | 26 | 25 | 25 | 27 | 24 | 25 | 24 | 24 | 290 |
| Omaha-Chicago | 23 | 22 | 26 | 24 | 26 | 26 | 24 | 24 | 25 | 26 | 19 | 22 | 287 |
| Chicago-Cleveland | 23 | 23 | 25 | 23 | 26 | 26 | 25 | 27 | 25 | 26 | 18 | 23 | 290 |
| Cleveland-New York | 19 | 20 | 22 | 22 | 25 | 26 | 25 | 25 | 24 | 25 | 16 | 24 | 273 |
| Average | 20.4 | 18.9 | 23.6 | 22.6 | 25.2 | 25.2 | 24.5 | 25.1 | 24.0 | 25.4 | 20.4 | 21.9 | 277 |
| Percentage of possible | 81.5 | 82.1 | 87.5 | 90.5 | 97.1 | 97.1 | 98.0 | 93.0 | 96.0 | 97.6 | 81.5 | 84.1 | 90.6 |
| Average, both ways | 20.4 | 18.2 | 23.9 | 22.9 | 25.1 | 25.1 | 24.6 | 25.1 | 23.6 | 25.3 | 20.1 | 21.4 | 276 |
| Percentage of possible | 81.8 | 79.1 | 88.4 | 91.5 | 96.4 | 96.6 | 98.2 | 92.8 | 94.2 | 97.4 | 80.5 | 82.5 | 90.1 |

An examination of the figures in this table brings out quite strikingly the following points:

(1) The number of flights each way, east and west, is approximately the same. Not only is this true for the different sections, but also for the individual months. There were a few exceptions but in general a failure to make a flight in any particular section applied to both directions on the same day. In other words, conditions that were unfavorable for flying were *altogether* unfavorable for it, regardless of direction. Among such conditions we may include rain and snowstorms, deep snow on the ground, fog, thunderstorms and excessively high winds. The last item, high winds, appears to have less importance than the others, so far as complete interruption of flight is concerned. Head winds do of course affect schedule performance—a phase of the subject that will be discussed later—but, unless their speed approaches closely, or exceeds, half that of the aircraft itself, they result only in delay, not in cancellation.

(2) In the present stage of development the summer half of the year is markedly superior to the winter half. From April to October the percentage of possible flights made is generally above 90, the average being about 95; in March it is only slightly less than 90; but from November to February it falls very nearly to 80. Here again we see the influence of unfavorable weather, such as fogs, rain or snow, poor visibility, etc., or bad condition of landing fields, due to rain or snow. Experience and improvement in facilities will at least partially overcome these conditions, but at present they constitute a real handicap for which proper allowance must be made.

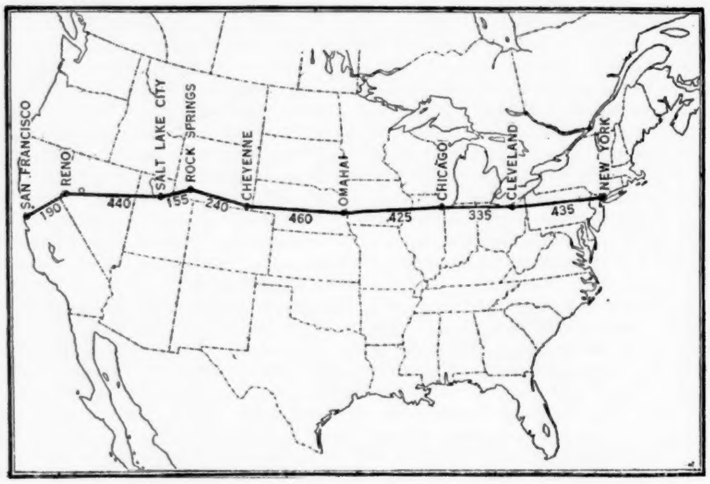


FIG. 1. Air Mail route between New York and San Francisco.

(3) For the year as a whole, there is little difference among the various sections of the route, with the one exception of that between Reno and San Francisco. Presumably this marked exception is due to other influences than that of weather, possibly topography, and little attention need therefore be given it here. Considering the other sections, we find particularly satisfactory the portion of the route between Cleveland and Salt Lake where more than 90 per cent of the scheduled trips were made; the percentage between New York and Cleveland and between Salt Lake and Reno is very close to 90. For the entire route the value is just above 90; if the section between Reno and San Francisco is disregarded, this value is about 92.

### THE FLIGHTS: THEIR AVERAGE SPEED.

The records furnished by the Air Mail Service give the actual time in which each flight was made. The data have been tabulated by months for each section of the course, averages have been determined and these averages have been converted into speeds in miles per hour, thus reducing all values to a uniform basis, independent of the length of the various sections. The number of flights used is slightly less than shown in Table 1, since it has been deemed wise to consider only those cases in which flights were made in both directions. The primary purpose of this study is to determine the wind fac-

tor as closely as possible, and this purpose would be defeated to some extent if days were included in which a flight was made in one direction and not in the other. However, this procedure resulted in a very small difference, amounting only to an average of 8 flights for each section for the entire year, and to 3 for the New York to Chicago portion of the course. The average speeds are given in Table 2, which also contains separate means for the comparatively level part of the course, New York to Cheyenne, and for the mountainous part, Cheyenne to San Francisco, and finally for all sections combined.

TABLE 2.—*Average speed, m. p. h., along Air Mail route.*

| Sections. | January. | February. | March. | April. | May. | June. | July. | August. | September. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Westbound. | | | | |
| New York-Cleveland | 89.5 | 84.8 | 90.4 | 87.3 | 95.8 | 88.2 | 84.5 | 87.0 | 86.1 |
| Cleveland-Chicago | 88.2 | 85.7 | 89.6 | 87.0 | 90.1 | 88.6 | 84.4 | 84.6 | 84.2 |
| Chicago-Omaha | 86.6 | 86.2 | 93.2 | 95.5 | 90.0 | 87.8 | 82.0 | 81.6 | 82.7 |
| Omaha-Cheyenne | 84.2 | 87.5 | 91.3 | 94.1 | 89.3 | 88.6 | 88.0 | 87.0 | 86.3 |
| Cheyenne-Rock Springs | 72.3 | 70.4 | 76.7 | 77.4 | 78.7 | 81.4 | 82.2 | 76.9 | 69.8 |
| Rock Springs-Salt Lake | 79.1 | 68.6 | 77.9 | 85.6 | 86.6 | 75.6 | 77.5 | 81.1 | 78.7 |
| Salt Lake-Reno | 94.2 | 91.9 | 92.4 | 95.2 | 94.8 | 87.3 | 92.4 | 93.2 | 88.9 |
| Reno-San Francisco | 100.5 | 100.0 | 90.9 | 96.4 | 97.4 | 82.6 | 85.6 | 84.1 | 88.0 |
| New York-Cheyenne | 87.0 | 86.1 | 91.2 | 91.1 | 91.3 | 88.3 | 84.7 | 85.0 | 84.9 |
| Cheyenne-San Francisco | 86.6 | 82.9 | 85.6 | 89.1 | 89.7 | 83.1 | 86.1 | 85.3 | 81.9 |
| New York-San Francisco | 86.8 | 84.8 | 89.0 | 90.3 | 90.7 | 86.2 | 85.3 | 85.2 | 83.7 |
| | | | | | Eastbound. | | | | |
| San Francisco-Reno | 93.1 | 91.3 | 106.1 | 102.7 | 97.4 | 88.4 | 90.9 | 94.5 | 99.0 |
| Reno-Salt Lake | 100.7 | 102.8 | 105.5 | 103.8 | 104.3 | 99.1 | 99.8 | 103.5 | 105.3 |
| Salt Lake-Rock Springs | 102.6 | 98.7 | 103.3 | 96.3 | 96.3 | 88.6 | 89.1 | 95.1 | 105.4 |
| Rock Springs-Cheyenne | 115.4 | 115.4 | 106.2 | 102.1 | 107.1 | 89.2 | 92.3 | 103.4 | 108.1 |
| Cheyenne-Omaha | 106.2 | 106.2 | 99.6 | 97.7 | 102.4 | 87.8 | 88.5 | 90.7 | 92.9 |
| Omaha-Chicago | 102.2 | 104.9 | 94.2 | 93.8 | 94.0 | 89.3 | 92.2 | 94.4 | 100.5 |
| Chicago-Cleveland | 104.7 | 102.4 | 93.8 | 104.0 | 94.1 | 88.6 | 92.3 | 92.8 | 97.4 |
| Cleveland-New York | 108.8 | 112.4 | 105.6 | 105.3 | 101.2 | 95.0 | 89.9 | 95.4 | 101.4 |
| San Francisco-Cheyenne | 102.5 | 102.4 | 105.5 | 102.0 | 102.3 | 92.9 | 94.6 | 100.4 | 104.7 |
| Cheyenne-New York | 105.5 | 106.6 | 98.4 | 99.8 | 98.1 | 90.1 | 90.5 | 93.3 | 97.9 |
| San Francisco-New York | 104.3 | 105.0 | 101.0 | 100.6 | 99.7 | 91.2 | 92.0 | 95.9 | 100.4 |

| Sections. | October. | November. | December. | Spring. | Summer. | Autumn. | Winter. | Annual. |
|---|---|---|---|---|---|---|---|---|
| | | | | Westbound. | | | | |
| New York-Cleveland | 85.1 | 84.1 | 89.5 | 91.2 | 86.6 | 85.1 | 87.9 | 87.7 |
| Cleveland-Chicago | 82.3 | 87.7 | 84.2 | 88.9 | 85.9 | 84.7 | 86.0 | 86.4 |
| Chicago-Omaha | 81.6 | 87.4 | 85.3 | 92.9 | 83.8 | 83.9 | 86.0 | 86.7 |
| Omaha-Cheyenne | 85.2 | 86.3 | 83.8 | 91.6 | 87.9 | 85.9 | 85.2 | 87.6 |
| Cheyenne-Rock Springs | 72.9 | 62.3 | 69.8 | 77.6 | 80.2 | 68.3 | 70.8 | 74.2 |
| Rock Springs-Salt Lake | 85.6 | 76.0 | 77.5 | 83.4 | 78.1 | 80.1 | 75.1 | 79.2 |
| Salt Lake-Reno | 90.5 | 88.0 | 88.4 | 94.1 | 91.0 | 89.1 | 91.5 | 91.4 |
| Reno-San Francisco | 88.0 | 86.4 | 93.1 | 94.9 | 84.1 | 87.5 | 97.9 | 91.1 |
| New York-Cheyenne | 83.6 | 86.3 | 85.7 | 91.2 | 86.0 | 84.9 | 86.3 | 87.1 |
| Cheyenne-San Francisco | 84.6 | 78.3 | 82.3 | 88.1 | 84.8 | 81.6 | 83.9 | 84.6 |
| New York-San Francisco | 84.0 | 83.0 | 84.4 | 90.0 | 85.6 | 83.6 | 85.3 | 86.1 |
| | | | | Eastbound. | | | | |
| San Francisco-Reno | 95.0 | 99.0 | 96.0 | 102.1 | 91.3 | 97.7 | 93.5 | 96.1 |
| Reno-Salt Lake | 99.1 | 107.8 | 99.8 | 104.5 | 100.8 | 104.1 | 101.1 | 102.6 |
| Salt Lake-Rock Springs | 105.4 | 103.3 | 97.5 | 98.6 | 90.9 | 104.7 | 99.6 | 98.5 |
| Rock Springs-Cheyenne | 104.3 | 117.6 | 113.7 | 105.1 | 95.0 | 110.0 | 114.8 | 106.2 |
| Cheyenne-Omaha | 100.4 | 102.9 | 106.0 | 99.9 | 89.0 | 98.7 | 106.1 | 98.4 |
| Omaha-Chicago | 98.4 | 96.8 | 101.4 | 94.0 | 92.0 | 98.6 | 102.8 | 96.8 |
| Chicago-Cleveland | 103.7 | 102.1 | 101.2 | 97.3 | 91.2 | 101.1 | 102.8 | 98.1 |
| Cleveland-New York | 103.8 | 97.5 | 109.0 | 104.0 | 93.4 | 100.9 | 110.1 | 102.1 |
| San Francisco-Cheyenne | 100.4 | 107.4 | 101.6 | 103.3 | 96.0 | 104.2 | 102.2 | 101.4 |
| Cheyenne-New York | 101.4 | 99.7 | 104.6 | 98.8 | 91.3 | 99.7 | 105.6 | 98.8 |
| San Francisco-New York | 101.0 | 102.5 | 103.4 | 100.4 | 93.0 | 101.3 | 104.2 | 99.8 |

Deferring for the present a detailed discussion of the figures in this table, we note that the average annual speed over all sections was 86 miles per hour for the westward trip and 100 for the eastward trip. These values indicate that the normal cruising speed of the planes was 93 m. p. h. and that the wind factor amounted to about 7 m. p. h. As a check on this latter value it is possible to use the results of free-air investigations that have been conducted with kites and pilot balloons. Let us first, however, discuss briefly the term "cruising speed" and determine, so far as possible, the altitude at which the flights were made. Unfortunately, these are subject to more or less uncertainty, as the following considerations will show:

1. Cruising speed:
   (*a*) With a high "head" wind pilots open the motor throttle, the result being a higher than normal airspeed.
   (*b*) Conversely, with a "tail" wind pilots ease up on the motor, and there results a lower than normal airspeed.
   (*c*) The effect of (*a*) and (*b*) is to give an apparent wind somewhat less than the actual wind in both cases.
2. Altitude:
   (*a*) In cold weather and against head winds; also, when there are low clouds or fog, pilots fly as low as possible, anywhere between 100 and 1,500 feet, probably less than 1,000 feet as a rule.
   (*b*) In warm weather, with good visibility, and especially if there is a tail wind, the flying is done at a much higher altitude, probably between 1,000 and 3,000 feet, sometimes higher still.
   (*c*) As a working basis we can assume 1,500 feet as the altitude of flight, a value which is believed to be not far from the average.

With both cruising speed and altitude unknown variables we can not fix accurately the actual wind. Nevertheless, it is to be noted that (*a*) and (*b*) under (1), and (*a*) and (*b*) under (2) are to some extent compensatory. That is to say, whereas flights in head winds are at a lower altitude than the average of 1,500 feet and therefore yield apparent winds of less speed than the actual wind at that level, yet on the other hand flights in tail winds are made at a higher altitude than the average with the result that the apparent wind speed is greater than the actual. Again, it should be borne in mind that many of the flights both east and west are made in easterly winds and that the statements in (1*a*) and (1*b*) apply to these as well as to westerly winds. Finally, in many cases no doubt, the motors failed to develop full power, even against high winds. It is thus seen that some of the elements of uncertainty offset one another, at least to a considerable extent. Assuming then that the average altitude of flight was 1,500 feet, that the average wind speed was 7 m. h. p., and that the normal cruising speed was 93 m. p. h., we shall now examine the results of free-air wind observations to provide, if possible, a check on these values.

## COMPARISON WITH FREE-AIR WIND OBSERVATIONS.

The data used in this comparison are those that have been obtained by means of kites and pilot balloons. By way of preface it may be remarked that neither method is entirely satisfactory. Balloons can be used only in clear weather, or at any rate only in the clear space beneath cloud layers; they can not be used when rain or snow is falling; since they travel with the wind, they

quickly disappear in a horizontal direction when winds are exceptionally strong. Kites, on the other hand, will not fly in very light winds, but are the means of procuring good records in cloudy weather and in fairly strong winds. The two methods thus supplement each other tolerably well, though not perfectly since neither is practicable during rain or snow. However, it is probable that an average of the results provides a close approximation to the true value, and this course has been pursued.

Unfortunately, free-air observations have not been made along all portions of the course, but the eastern part of the country has been fairly well covered. The records chosen for the present study were obtained by means of kites at Drexel, Nebr., and Royal Center, Ind.; and by means of pilot balloons at 2 groups of stations, hereinafter to be referred to as Group 1 and Group 2, the first one comprising Burlington, Vt., Ithaca, N. Y., Lansing, Mich., and Madison, Wis.; and the second, McCook Field, Ohio, Park Field, Tenn., Royal Center, Ind., West Point, Ky., and Wright Field, Ohio.[2] All of these stations are fairly close to the Air Mail route. The individual observations have been added vectorially and the results are presented in Table 3.

TABLE 3.—*Resultant winds, m. p. h. at 1,500 feet above surface.*

| Stations. | Method of observation. | Number of observations. | Resultant winds. |
|---|---|---|---|
| Drexel, Nebr. | Kites | 1,891 | S. 65° W. 4.9. |
| Royal Center, Ind. | do | 607 | S. 60° W. 10.3. |
| Group 1 | Balloons | 3,874 | S. 88° W. 8.7. |
| Group 2 | do | 2,895 | S. 68° W. 7.8. |

The rather large difference between the resultant wind at Drexel and that at the other stations appears to be due to the greater frequency of winds from directions between south and west at the latter. At Drexel winds are about equally frequent from the northwest and southwest quadrants. The values in Table 3 have been resolved into south and west components, and the mean resultant wind is found to be S 70° W 7.7. The average bearing of the course from New York to San Francisco is S 86° W. The difference between this and the resultant wind, S 70° W, viz. 16°, is the angle to be considered in determining wind effect. In order to keep on its course, the airplane must necessarily make a small angle with that course to offset the wind when the latter is neither a straight head wind nor a straight tail wind. This angle will depend upon the direction of the wind and upon its speed relative to that of the plane. It is easily determined from the equation,

$$\sin \beta = \frac{S_w}{S_a} \sin \alpha, \qquad (1)$$

in which $\beta$ = the angle between the plane and the course;
$\alpha$ = the angle between the wind and the course;
$S_a$ = cruising speed of the airplane;
and $S_w$ = the speed of the wind.

In the present case $\sin \beta = \frac{7.7}{93} \sin 16° = .0228.$

$$\beta = 1°$$

[2] The length of the record varies somewhat for the different stations, but on the average is about 3 years.

The resultant, or ground, speed, $S_r$, of the airplane will then be

$$\begin{aligned} S_r &= S_a \cos \beta \pm S_w \cos \alpha \qquad (2) \\ &= 93 \cos 1° \pm 7.7 \cos 16° \\ &= 93 \pm 7.4 \\ &= 100.4 \text{ or } 85.6 \end{aligned}$$

These results agree very satisfactorily with the values determined from the actual record of flights, viz., 99.8 and 86.1, respectively, and indicate that we are entirely justified in accepting 7 miles per hour as the effective wind factor in the Air Mail flights. They indicate further that the average effect on any flight schedule may be closely predicted from the resultant wind and the normal cruising speed, even though the cruising speed and altitude are to some extent varied. If these are known more definitely, then the resultant winds determine still more precisely what allowance should be made, a matter of considerable significance in commercial aviation enterprises and one emphasing the importance of extending free-air investigations to all parts of the country as speedily as possible.

## VARIATIONS FROM THE AVERAGE.

A knowledge of average performance is important, but it is not sufficient for the purposes of commercial aviation. It is essential also to know the percentage of flights that are delayed and to fix schedules for which the percentage of delays will not exceed certain limiting values. For example, if a contractor wishes to guarantee arrival within schedule limits 95 per cent of the time, he must know the speed of which his planes are capable and he must know the wind velocity which at the selected flying level, is not exceeded more than 5 per cent of the time. With these data, and such allowance for service stops, etc., as is necessary, he can determine a working flight schedule. We shall now examine in greater detail the Air Mail records and the kite and balloon data, with a view to determining what percentage of trips are likely to be delayed with various time schedules; special attention will then be given to that portion of the route between New York and Chicago; and finally the results of the study will be applied to aircraft of various speeds between 50 and 150 m. p. h.

The normal cruising speed of an airplane probably averages from 80 to 90 per cent of its maximum speed. The latter is rarely used, but it constitutes a valuable reserve in case of high head winds or unexpected delays in starting, etc. In all probability, however, a speed closely approaching this maximum is frequently resorted to. This we shall call the plane's "high cruising speed." We shall also assume that the ratio between this and the normal cruising speed is 1 to 0.85.

Let $S$ = high cruising speed,
$0.85S$ = normal cruising speed,
$R$ = resultant wind, or wind factor,
and $S_r$ = plane's resultant or "ground" speed.

We have already found that, for the Air Mail, $0.85S = 93$. Then $S = 110$, a speed which we assume can be resorted to in case of high head winds. We have found also that $R = 7$, and $S_r$, for westward flights, $= 86$, and for eastward, 100.

DELAYS IN WESTWARD FLIGHTS.

As already stated, $S_r = 86$ for these flights. The following table shows the percentage of flights that were made at a lower speed than this.

TABLE 4.—*Percentage of flights westward at less than 86 m. p. h.*

| Sections. | Total. | Delays. | Percentage. |
|---|---|---|---|
| New York-Cleveland | 269 | 114 | 42 |
| Cleveland-Chicago | 287 | 130 | 45 |
| Chicago-Omaha | 278 | 128 | 46 |
| Omaha-Cheyenne | 277 | 113 | 41 |
| Cheyenne-Rock Springs | 267 | 210 | 79 |
| Rock Springs-Salt Lake | 274 | 188 | 69 |
| Salt Lake-Reno | 264 | 47 | 18 |
| Reno-San Francisco | 224 | 74 | 33 |
| Total | 2,140 | 1,004 | 47 |

An inspection of these figures (see also Table 2 in this connection) shows that there is little variation along the different portions of the course from New York to Cheyenne, the average percentage of delays being about 45, thus agreeing closely with the general average. Over the Rocky Mountain region, however, i. e., from Cheyenne to Salt Lake, the percentage of delays is much higher, about 75, probably due in part to greater difficulty in keeping the course because of low-lying clouds, and in part also to stronger westerly winds, since flying is done at a greater altitude above sea level. West of the Rockies, i. e., from Salt Lake to San Francisco, the percentage of delays is much smaller than over any other parts of the course, amounting to only 25. It is not easy to account for this, but the explanation may be that the winds in this region have a less pronounced west component. This appears to be the case, judging from the pilot-balloon observations that have thus far been made. These are not sufficient in number, however, to justify a positive statement on this point.

A more detailed inspection of the original data, of which Table 4 merely gives a summary, indicates that at all points along the course there is a decided seasonal variation. The percentage of delays by seasons for all sections combined is as follows: Spring, 35; summer, 51; autumn, 55; winter, 48.

At first thought we would expect this variation to manifest itself as a small percentage of delays in summer and a large one in winter, but such is not the case. Instead, the minimum is found in spring, the maximum in autumn, and the summer and winter values are nearly identical. It is certain that the west component in the winds is much greater in winter than in summer; and the only plausible explanation for the unexpected results above given seems to be that, in flying against head winds in winter, pilots open the motor throttle to the "high" instead of the "normal" cruising speed. Moreover, as indicated earlier, pilots fly at a lower altitude in winter than in summer, and this tends to offset the difference in wind effects of the two seasons. In spring, because of the prevalence of cloudy weather, the flying is still done at a low altitude, and thus fewer delays occur than in summer because of the difference in altitude or than in winter because of the decreased wind speeds at about the same altitudes. In autumn the reverse is true in each case, because of the greater altitude followed on account of the relatively clear weather.

DELAYS IN EASTWARD FLIGHT.

In this case $S_r = 93 + 7 = 100$. Table 5 shows the percentage of flights that were made at a lower speed than this.

TABLE 5.—*Percentage of flights eastward at less than 100 m. p. h.*

| Sections. | Total. | Delays. | Percentage. |
|---|---|---|---|
| San Francisco-Reno | 224 | 133 | 59 |
| Reno-Salt Lake | 264 | 94 | 36 |
| Salt Lake-Rock Springs | 274 | 134 | 49 |
| Rock Springs-Cheyenne | 267 | 99 | 37 |
| Cheyenne-Omaha | 277 | 151 | 55 |
| Omaha-Chicago | 278 | 164 | 59 |
| Chicago-Cleveland | 287 | 161 | 56 |
| Cleveland-New York | 269 | 109 | 41 |
| Total | 2,140 | 1,045 | 49 |

The average percentage of delays for all parts of the course is 49, practically the same as for the westward flights, the resultant wind being allowed for in each case.

When examined in detail, the original records show a marked seasonal variation as follows: Spring, 44; summer, 73; autumn, 39; winter, 35.

This variation accords with what one would expect and is easily explained: In summer all winds are prevailingly light and therefore material assistance from westerly winds is not frequently experienced. The occurrence of thunderstorms, moreover, adds to the number of delayed flights; in winter marked assistance from westerly winds is frequently found. Even when easterly winds occur, they are not usually very strong at low altitudes, and are not infrequently overrun by westerly winds. The pilot thus can fly above them and gain speed from the overlying westerlies, or in them and be but little delayed by their comparatively low speeds. An exception is to be noted in the part of the course from San Francisco to Salt Lake, where the percentage of delays in winter is nearly as high as in summer. This seems to confirm the remark made earlier that westerly winds in this region of the country are less vigorous than farther east.

From the foregoing discussion it is evident that the number of flights in each direction made at a higher speed and at a lower speed respectively than the average value of $S_r$ is approximately the same, viz, 50 per cent. From an operation standpoint we are little interested in advances on schedule, but we are *vitally* interested in delays. It is thought worth while therefore to assume certain arbitrary schedules, or in other words adopt certain factors of safety, and from the records determine the percentage of flights that fail to arrive within schedule and the average and maximum delay for these flights.

WESTWARD FLIGHT: FACTOR OF SAFETY, 15 M. P. H. HEAD WIND AT NORMAL CRUISING SPEED, OR 32 M. P. H. AT HIGH CRUISING SPEED.

Under this assumption, $S_r = 93 - 15 = 78$. Table 6 shows the percentage of flights that were made at a slower speed than this.

TABLE 6.—*Percentage of flights westward at less than 78 m. p. h.*

| Sections. | Total. | Delays. | Percentage. |
|---|---|---|---|
| New York-Cleveland | 269 | 43 | 16 |
| Cleveland-Chicago | 287 | 63 | 22 |
| Chicago-Omaha | 278 | 53 | 19 |
| Omaha-Cheyenne | 277 | 36 | 13 |
| Cheyenne-Rock Springs | 267 | 155 | 58 |
| Rock Springs-Salt Lake | 274 | 115 | 42 |
| Salt Lake-Reno | 264 | 12 | 4 |
| Reno-San Francisco | 224 | 23 | 10 |
| Total | 2,140 | 500 | 23 |

From these figures it appears that the schedule could not be kept more than about 75 per cent of the time. As in the previous case, however, where a head wind of 7 m. p. h. was allowed, the delays are most frequent, about 50 per cent, in the Rocky Mountain region. If we consider the course from New York to Cheyenne, the percentage of arrivals on or ahead of schedule becomes 82, with a small seasonal variation from 85 in spring and summer to 79 in autumn and winter. It is evident that this performance would not be satisfactory and should be remedied either by using machines having a higher cruising speed, or by allowing a greater factor of safety.

Table 7 shows the average and maximum delay for the different sections of the course for the schedule on which Table 6 is based.

TABLE 7.—*Average and maximum delay, in minutes, for those flights that failed to arrive within schedule.*

| Sections. | Average delay. | Maximum delay. |
|---|---|---|
| New York–Cleveland | 20 | 55 |
| Cleveland–Chicago | 23 | 97 |
| Chicago–Omaha | 34 | 121 |
| Omaha–Cheyenne | 15 | 39 |
| Cheyenne–Rock Springs | 30 | 160 |
| Rock Springs–Salt Lake | 14 | 80 |
| Salt Lake–Reno | 29 | 97 |
| Reno–San Francisco | 13 | 37 |

Considering the New York to Chicago part of the course as a unit, we obtain the following values:

Percentage of delays, 19

Average delay in minutes, 26[3]

Maximum delay in minutes, 101[3]

The first value, 19 per cent, agrees closely with the average of the values shown in Table 6 for the four sections from New York to Cheyenne. From these it might at first thought be assumed that head winds of more than 15 miles per hour are encountered less than 20 per cent of the time. This of course is not true; rather, when stronger winds do occur, the reserve power of the motor, $S-0.85\ S$, or at any rate part of it, is brought into play. If $S=110$, then the schedule based on 78 m. p. h. could be maintained, other conditions being favorable, against all head winds up to $15+(110-93)=32$ m. p. h. But the results show that this schedule was maintained only about 80 per cent of the time, which means either that head winds above 32 m. p. h. prevailed on one day out of five, or that poor visibility, engine trouble and other causes, not at all related to the wind, operated to cut down the value of S considerably below 110. In order to determine what proportion of these delays can be attributed to adverse winds a large number of balloon and kite records have been examined and the results are given in the following paragraphs.

For the present purpose the route is sufficiently close to a west-east line to be considered such. If then a wind is blowing straight from that direction, i. e., west, the plane will be delayed in its flight by exactly the speed of that wind. If, however, the wind is from some other direction with a west component, the delay will be less than the speed of the wind, the amount of the decrease being least with WSW or WNW, and greatest with SSW or NNW winds. By transformation of equation (2) it is easy to compute the speeds of wind from the different directions that will produce a resultant delay of 32 m. p. h. in the plane's progress.[4] These values are as follows:

| | M. p. h. |
|---|---|
| W | 32 |
| WNW or WSW, approximately | 36 |
| NW or SW, approximately | 40 |
| NNW or SSW, approximately | 50 |

The kite and balloon records chosen for the study are the same as those used in the preparation of Table 3. The observations, 9,267 in number, were examined, and those tabulated in which the velocities for the appropriate directions equaled or exceeded the values above listed. The results are shown in Table 8.

TABLE 8.—*Percentage frequency of winds at 1,500 feet altitude with west component equaling or exceeding 32 m. p. h.*

| Stations. | Method of observation. | Number of observations. | Number with west component 32 m. p. h. or more. | Percentage |
|---|---|---|---|---|
| Drexel, Nebr | Kites | 1,891 | 193 | 10.2 |
| Royal Center, Ind | do | 607 | 47 | 7.7 |
| Group 1 | Balloons | 3,874 | 183 | 4.8 |
| Group 2 | do | 2,895 | 193 | 6.7 |
| Mean | | | | 7.4 |

From the mean value here given it appears that head winds would cause a delay in the schedule about once in every two weeks, or in other words that satisfactory performance could be guaranteed 90 per cent of the time, *so far as wind is concerned.* Part of the 23 per cent delayed trips actually experienced, as shown in Table 6, are therefore attributable to other causes, such as failure of engines to develop full power, flying a roundabout route or at high altitudes because of low clouds, etc.

## OTHER SELECTED FACTORS OF SAFETY.

The foregoing method of comparing the delays in flights with kite and balloon data has been applied to other assumed factors of safety. It is hardly necessary to give the results at length in this paper, but the detailed figures are available for any who may be interested in them. A general summary follows:

(*a*.) *Westward flight: Factor of safety, 25 m. p. h. at normal cruising speed, or 42 m. p. h. at high cruising speed.*—$S_r=93-25=68$: The average percentage of delays for this schedule was 6, with highest values between Cheyenne and Salt Lake. From New York to Chicago it was only 3 per cent, the average delay being 18 minutes. This is in good agreement with kite and balloon records, which show that winds with a west component of 42 m. p. h. occur 2 per cent of the time. Evidently then this schedule would be very satisfactory, since delays would be experienced about once in 7 weeks.

(*b*.) *Eastward flight: Factor of safety, 10 m. p. h. at normal cruising speed, or 27 m. p. h. at high cruising speed.*—$S_r=93-10=83$: Smaller factors of safety are used for eastward flight, since head winds, in this case easterly winds, are of less average speed than for westward flight. The average percentage of delays for the entire course was 9, with no great variation in the different sections. From Chicago to New York it was 8 per

[3] There is an apparent discrepancy here between the average and maximum delays for the combined course, New York to Chicago, and the sums of the values given in Table 7, where the two sections, New York to Cleveland and Cleveland to Chicago are considered separately. This is easily explained. In many cases there was a delay in one section, but this was more than made up in the other, with the result that there was no delay whatever in the complete trip. For example, calling the three places A, B, and C, let us assume that on one day flight was made 40 minutes ahead of schedule from A to B and was 30 minutes delayed from B to C; and that the reverse of this occurred on the next day. For the entire trip there was no delay on either day but for each section separately there was one delay of 30 minutes to be included in the results given in Table 7.

[4] It is to be noted that allowance is made in equation (2) for the angle that the airplane must make with the course in order to keep on that course.

cent, with an average delay of 43 minutes. Kite and balloon records show that winds with an east component of 27 m. p. h. occur 2.4 per cent of the time, which means that other factors, previously mentioned, were responsible for some of the delays. Considering wind only, and assuming that S = 110, we can safely conclude that this schedule could be maintained 97 per cent of the time, i. e., delays would occur once in 5 weeks.

(*c*.) *Eastward flight: Factor of safety, 20 m. p. h. at normal cruising speed, or 37 m. p. h. at high cruising speed.*—$S_r = 93 - 20 = 73$: The percentage of delays for each section of the course was 4 or less, the average for the entire course being 2 per cent, and for Chicago to New York 1 per cent. Kite and balloon data indicate that winds with an east component of 37 m. p. h. occur 0.7 per cent of the time, from which it appears not only that the agreement is remarkably close but also that this schedule would be a particularly satisfactory one, with delays occurring about 4 times a year.

### FLYING BETWEEN NEW YORK AND CHICAGO.

Thus far we have been considering in more or less general terms the entire Air Mail course from New York to San Francisco. At the present time interest is most keen in that portion of it between New York and Chicago, partly because of the commercial importance of those two cities and of others along the route and partly for the reason that if aviation can be proved to be practicable in this region, characterized as it is by frequent storms, high winds and poor visibility, it will certainly be practicable, so far as weather is concerned, in almost any other part of the country. In what follows, therefore, we shall discuss in somewhat greater detail the wind conditions along this portion of the course, as revealed by the Air Mail records and by kite and balloon data. The length of the course is 770 miles. Only those days have been considered in which flights covered this entire distance in both directions. There were thus excluded 3 days in which flights were made from New York to Chicago but not in the other direction; 6 days in which the performance was the reverse of this; and 12 days in which flights were made over only a part of the course either way, e. g., New York to Cleveland, but not on to Chicago, etc.

The number of flights considered is shown, by months, seasons and the year, in Table 9, which also contains the number of available days, excluding Sundays and holidays; the percentage of days on which flights were made; the average speed attained in each direction; and the highest and lowest speeds.

TABLE 9.—*Miscellaneous statistical data for flights between New York and Chicago.*

| | January. | February. | March. | April. | May. | June. | July. | August. | September. |
|---|---|---|---|---|---|---|---|---|---|
| Number of days, excluding Sundays and holidays | 25 | 23 | 27 | 25 | 26 | 26 | 25 | 27 | 25 |
| Number of flights each way | 19 | 17 | 21 | 21 | 25 | 26 | 25 | 25 | 24 |
| Percentage of possible | 76.0 | 73.9 | 77.8 | 84.0 | 96.2 | 100.0 | 100.0 | 92.6 | 96.0 |
| | New York-Chicago. | | | | | | | | |
| Average speed m. p. h | 88.8 | 86.3 | 90.3 | 87.4 | 93.3 | 88.4 | 84.1 | 85.7 | 85.6 |
| Highest speed m. p. h | 114.1 | 110.3 | 108.0 | 106.1 | 111.9 | 104.1 | 97.5 | 99.6 | 101.3 |
| Lowest speed m. p. h | 68.7 | 71.3 | 74.6 | 70.8 | 77.1 | 73.2 | 73.5 | 75.7 | 65.9 |
| | Chicago-New York. | | | | | | | | |
| Average speed m. p. h | 107.2 | 107.8 | 100.0 | 104.2 | 98.0 | 92.1 | 90.9 | 94.1 | 99.4 |
| Highest speed m. p. h | 129.4 | 129.2 | 123.4 | 130.5 | 115.8 | 110.2 | 111.3 | 111.9 | 128.3 |
| Lowest speed m. p. h | 84.6 | 89.0 | 77.7 | 76.6 | 78.8 | 75.1 | 64.3 | 75.3 | 79.1 |

TABLE 9.—*Miscellaneous statistical data for flights between New York and Chicago*—Continued.

| | October. | November. | December. | Spring. | Summer. | Autumn. | Winter. | Annual. |
|---|---|---|---|---|---|---|---|---|
| Number of days, excluding Sundays and holidays | 26 | 25 | 26 | 78 | 78 | 76 | 74 | 306 |
| Number of flights each way | 24 | 14 | 20 | 67 | 76 | 62 | 56 | 261 |
| Percentage of possible | 92.3 | 56.0 | 76.9 | 85.9 | 97.4 | 81.6 | 75.7 | 85.3 |
| | New York-Chicago. | | | | | | | |
| Average speed m. p. h | 84.2 | 85.8 | 87.0 | 90.3 | 86.0 | 85.2 | 87.4 | 87.2 |
| Highest speed m. p. h | 119.0 | 109.5 | 104.5 | 111.9 | 104.1 | 119.0 | 114.1 | 119.0 |
| Lowest speed m. p. h | 68.1 | 74.0 | 71.0 | 70.8 | 73.2 | 65.9 | 68.7 | 65.9 |
| | Chicago-New York. | | | | | | | |
| Average speed m. p. h | 104.1 | 100.4 | 105.5 | 100.7 | 92.3 | 101.3 | 106.8 | 100.3 |
| Highest speed m. p. h | 136.3 | 129.8 | 124.8 | 130.5 | 111.9 | 136.3 | 129.4 | 136.3 |
| Lowest speed m. p. h | 79.4 | 82.2 | 91.3 | 76.6 | 64.3 | 79.1 | 84.6 | 64.3 |

From the values given in the third line of this table it is apparent that one year's record is not sufficient for the determination of monthly averages; a longer record would smooth out some of the abrupt irregularities. For example, the value for November is much lower than it would be as a rule, and for that matter considerably lower than the general average for the entire route between New York and San Francisco, as may be seen by a glance at Table 1. The large difference between this November value and those for other months, appears to be due to the unusual amount of storminess in the eastern States, resulting from marked cyclonic activity. During the month there was more than double the normal number of cyclones, i. e., low pressure areas, and these produced much cloudiness, accompanied by snow and rain. In spite of this evidently abnormal month, as well as some lesser irregularities in the values given in the table, the latter do bring out, in no uncertain fashion, the marked superiority of the summer over the winter half of the year. From May to October, inclusive, more than 95 per cent of the scheduled flights were made, but the average for the remaining 6 months drops down to about 75 per cent. It is noteworthy that in June and July every flight scheduled was made. Yet these are the months in which most thunderstorms occur in this region. Evidently thunderstorms and local showers do not constitute a serious deterrent to flight. They make necessary a wide detour sometimes and therefore cause delays, but they rarely prevent altogether the completion of a flight. The widespread occurrence of low clouds, however, accompanied as they usually are by rain or snow and characterized by poor visibility, is at present a very big problem for the elimination of which commercial aviation must marshal all its forces. Rain not only interferes with flight but sometimes produces conditions at landing fields which render the take-off and landing difficult and even dangerous. Snow is likewise an impediment in flight and in addition tends to obliterate markings along the route on which the pilot depends for his guidance. If of considerable depth, it may make the take-off and landing of planes hazardous or in extreme cases quite impossible.

The hopeful aspect of this problem is that in large measure it can be solved; there are no insuperable difficulties. Navigation methods must be improved to enable the pilot to fly above the cloud layers and still keep his course. Even in widespread storms there are occasional lulls. Meteorological service must be so en-

larged and improved as to enable pilots, by timely warnings, to take advantage of these lulls. Slight delays may result, but at any rate not complete interruption. Suitable signals, both radio and beacon, must be developed so that pilots may be largely independent of such markings as those upon which reliance is now placed. Landing fields must be so graded, drained, and surfaced that rains will have no deleterious effect upon them, and provision must be made to prevent the accumulation of soft snow. By these and other measures the regularity of flight will certainly be greatly improved. In all probability such improvement will be effected in the near future. At present, however, we are more interested in what has actually been accomplished in spite of handicaps, and it seems pertinent, therefore, to consider briefly the days in which flights were not completed in both directions. There were 45 such days, not including Sundays and holidays. A study of the meteorological conditions on those days indicates that 29 of them were very unfavorable for flight. One occurred in May, 2 in August, 1 each in September and October, and the remaining 24 from November to March, inclusive. In all of these 29 cases there was widespread snow or rain, the former prevailing on 13 days. It can not be denied, however, that several of these days were no more unfavorable than were several others during the year on which flights were completed in both directions, and it seems fair to assume, therefore, that other causes contributed in part at least to some of these failures. These "other causes," which may include accidents to the planes, engine trouble, etc., were almost certainly responsible for failures on the remaining 16 of the 45 "flightless" days, since meteorological conditions were good along most of the route on those days. If we include these 16 days with the annual total of 261 in Table 9, we would have a percentage of possible flights amounting to 90.5. If we further assume that flights could have been made on half of the 29 unfavorable days (and this is an entirely justifiable assumption, based on a comparison of those days with several other worse days on which flights were made) the percentage would be 95.1.[5]

Before leaving this part of the subject it is believed worth while to discuss briefly the year as a whole, so far as weather in the region between New York and Chicago is concerned. Temperature was practically normal in January, August, and November; in other months there was an excess of 2° to 6° F., the average for the year being about 3° F. above normal. There were no large abnormalities in precipitation: May and July were close to normal, March, April, and August to November had a slight excess; and June, and December to February, a small deficiency. In no case was the departure more than 1.5 inches in a month. For the year the total was about 2 inches above normal. When we consider storm movement, however, we find considerably greater activity than in most years, only one month, June, showing less. We have already commented on this feature of the weather in November. For the year as a whole, cyclonic areas were about 60 per cent more frequent than normal. Although there were no more than the usual number of storms of marked severity, the large number of moderate storms necessarily produced more frequent changes in weather and a greater amount of cloudiness than would be experienced in most years. Hence, it can be stated quite definitely that the year under consideration provided a rather more severe test for flying between New York and Chicago than would the normal year, and it seems reasonable to conclude that, so far as weather conditions are concerned, flights could be made in both directions between New York and Chicago more than 95 per cent of the time. This statement does not refer to the maintenance of any particular time schedule—a subject to which we shall now turn our attention.

Average, highest and lowest speeds for the westward and eastward flights and for the months, seasons, and the year as a whole, are shown in the last 6 lines of Table 9. From an operation standpoint it is of value to consider each day's flights in connection with the meteorological conditions, but such detailed discussion is of course out of the question. It has been deemed worth while, however, to consider briefly the extreme cases, and the results of this examination are presented in Table 10.

TABLE 10.—*Meteorological conditions on days when highest and lowest speeds were made.*

| Season. | Speed. | Date. | Meteorological conditions. |
|---|---|---|---|
| | | | Highest speeds westward. |
| | *M. p. h.* | | |
| Spring.... | 111.9 | May 27, 1922 | Easterly winds and clear weather. High north of Lake Superior. |
| Summer.. | 104.1 | June 2, 1921 | Light easterly winds and clear weather. High over New England; low over Wisconsin. |
| Autumn.. | 119.0 | Oct. 26, 1921 | Easterly winds and clear weather. High over St. Lawrence Valley. |
| Winter.... | 114.1 | Jan. 27, 1922 | Do. |
| | | | Lowest speeds westward. |
| Spring.... | 70.9 | Apr. 20, 1922 | Strong westerly winds and cloudy weather. Vigorous low over St. Lawrence Valley. |
| Summer.. | 73.2 | June 13, 1921 | Moderate westerly winds and partly cloudy weather with some thunderstorms. Moderate low over St. Lawrence Valley; moderate high in Southern States. |
| Autumn.. | 65.9 | Sept. 22, 1921 | Strong westerly winds and clear weather. Vigorous low north of Great Lakes, with steep pressure gradient south to north. |
| Winter.... | 68.7 | Jan. 5, 1922 | Strong westerly winds and stormy weather. Vigorous low east of Lake Huron. |
| | | | Highest speeds eastward. |
| Spring.... | 130.5 | Apr. 20, 1922 | (See under "Lowest speeds westward.") |
| Summer.. | 111.9 | Aug. 18, 1921 | Strong northwesterly winds and partly cloudy weather. Vigorous low over St. Lawrence Valley. |
| Autumn.. | 136.3 | Oct. 22, 1921 | Strong westerly winds and clear weather. Vigorous low north of Lake Huron, with steep pressure gradient south to north. |
| Winter.... | 129.4 | Jan. 4, 1922 | Strong southwesterly winds and comparatively clear weather. Vigorous low over Manitoba. |
| | | | Lowest speeds eastward. |
| Spring.... | 76.6 | Apr. 17, 1922 | Strong southerly winds and stormy weather. Vigorous low over Michigan. |
| Summer.. | 64.3 | July 6, 1921 | Light variable winds and occasional thunderstorms. Typical "flat map." |
| Autumn.. | 79.1 | Sept. 15, 1921 | Light, variable winds and cloudy weather. No pronounced high or low. |
| Winter.... | 84.6 | Jan. 27, 1922 | (See under "Highest speeds westward.") |

NOTE.—The terms "high" and "low" refer to centers of high and low pressure, respectively. A high north, or a low south, of the course is accompanied by easterly winds along that course; the reverse position of high or low brings westerly winds. The relation between the location of high and low pressure and the highest and lowest speeds attained in flight is well brought out in the figures and remarks above given.

This table shows a striking similarity in the weather conditions that are responsible for high and low speeds in each direction, viz., strong tail winds with clear weather and strong head winds with stormy weather respectively. Two apparent exceptions are noted, on July 6 and September 15, 1921, under "Lowest speeds eastward." Light variable winds prevailed in each case and the weather was fairly good. It is probable that other

[5] This assumption finds further support in a recent report of the Air Mail Service, wherein it is shown that during the calendar year 1922 an efficiency of 95.5% was maintained.

causes, e. g., engine trouble, etc., contributed to these two delays. The highest speed attained in the year, 136.3 m. p. h., on October 22, 1921, was made under almost ideal conditions—clear weather and pressure lines close together and nearly paralleling the latitude.

Reverting now to Table 9, we find that the seasonal variation in the average speeds maintained is very similar to that for the entire course between New York and San Francisco, as shown in Table 2. This variation has already been discussed (third paragraph, following Table 4) and need not be referred to further here. We shall now take the seasonal values and the annual mean and compare them with resultant winds, as determined by means of observations with kites and balloons. The seasonal and annual means are taken from Table 9. The normal cruising speed and the wind factor are then determined, as already indicated in the discussion following Table 2. Finally the resultant wind for each season has been computed in the same way as has that for the year, using the kite and balloon records referred to in the paragraph preceding Table 3. These records serve the present purpose even better than the more general one, i. e., the entire transcontinental course, since they were obtained at stations all of which are comparatively near the Chicago to New York part of the route. The data above outlined are assembled in Table 11.

TABLE 11.—*Mean seasonal and annual speed of flights, m. p. h. between New York and Chicago; also, comparison between wind factor determined therefrom and resultant wind from aerological observations.*

| | Spring. | Summer. | Autumn. | Winter. | Annual. |
|---|---|---|---|---|---|
| Average speed: | *M. p. h.* | *M. p. h.* | *M. p. h.* | *M. p. h.* | *M. p. h.* |
| New York-Chicago | 90.3 | 86.0 | 85.2 | 87.4 | 87.2 |
| Chicago-New York | 100.7 | 92.3 | 101.3 | 106.8 | 100.3 |
| Normal cruising speed | 95.5 | 89.2 | 93.2 | 97.1 | 93.8 |
| Wind factor from data above given | 5.2 | 3.2 | 8.0 | 9.7 | 6.6 |
| Resultant wind from kite and pilot balloon records | 5.4 | 5.6 | 8.7 | 10.7 | 7.4 |

The annual cruising speed, 93.8 m. p. h., in line 3 of this table is in striking agreement with that found for the entire route between New York and San Francisco, viz., 93.0 m. p. h. This slight difference is of no real significance, but it may be remarked that the higher value for the eastern section of the course is probably due to the exceptionally favorable conditions for westward flight in the month of May, resulting in a higher average speed than was maintained in any other month. (See Table 9.) It seems proper to make some allowance for this, and we shall therefore continue to use 93 m. p. h. as the normal cruising speed. The values in the table show a seasonal variation, but this does not mean that the normal cruising speed itself varies. Rather, in winter the winds from all directions are stronger than in summer. In winds approximately parallel with the course, the assistance in one direction is offset by the resistance in the other, or nearly so; but in many cases cross winds prevail and it then becomes necessary to increase the speed of the airplane in *both* directions, the result being to give a mean speed which is somewhat higher than the annual cruising speed. In summer, the delays are caused to a less extent by winds than by thunderstorms, squalls, etc., which necessitate flying off course. Such delays are experienced in both westward and eastward flight, and result in cutting down the average speed somewhat below the normal cruising speed. The variations are not large, however, amounting to less than 5 m. p. h. in each season. Even the monthly values, though based on a small number of cases, show almost equally satisfactory agreement, as follows:

| | Average m. p. h. |
|---|---|
| January | 98.0 |
| February | 97.0 |
| March | 95.2 |
| April | 95.8 |
| May | 95.6 |
| June | 90.2 |
| July | 87.5 |
| August | 89.9 |
| September | 92.5 |
| October | 94.2 |
| November | 93.1 |
| December | 96.2 |

The last two lines of Table 11 give a comparison of the wind factor, indicated by mean westward and eastward speeds, and the resultant winds, as observed by means of kites and balloons. Except in summer the agreement is close, the resultant wind being slightly the higher of the two in all seasons. In summer various factors of uncertainty, already referred to, such as thunderstorms, squalls, etc., tend to mask the effects of winds which for the most part are light and variable. It is therefore not surprising to find a fairly large difference in this season. The agreement in the means for the year is excellent, each being close to 7 m. p. h., which is the value already used for the entire transcontinental route.

In Tables 12 and 13 the Air Mail records are presented in such form as to show the number and percentage of flights that were made at or above different average speeds. The figures in the second column of the tables give the equivalent duration of the flights in hours and hundredths.

TABLE 12.—*Number and percentage of flights made from New York to Chicago at or above different average speeds.*

| Speed (m. p. h.). | Time of flight. | Spring. | Summer. | Autumn. | Winter. | Annual. | Spring. | Summer. | Autumn. | Winter. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of flights. | | | | | Percentage of total number. | | | | |
| | *Hrs.* | | | | | | | | | | |
| 120 | 6.42 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 118 | 6.53 | 0 | 0 | 1 | 0 | 1 | 0.0 | 0.0 | 1.6 | 0.0 | 0.4 |
| 116 | 6.64 | 0 | 0 | 1 | 0 | 1 | 0.0 | 0.0 | 1.6 | 0.0 | 0.4 |
| 114 | 6.75 | 0 | 0 | 1 | 0 | 1 | 0.0 | 0.0 | 1.6 | 0.0 | 0.4 |
| 112 | 6.88 | 0 | 0 | 1 | 1 | 2 | 0.0 | 0.0 | 1.6 | 1.8 | 0.8 |
| 110 | 7.00 | 2 | 0 | 1 | 2 | 5 | 3.0 | 0.0 | 1.6 | 3.6 | 1.9 |
| 108 | 7.13 | 2 | 0 | 2 | 2 | 6 | 3.0 | 0.0 | 3.2 | 3.6 | 2.3 |
| 106 | 7.26 | 5 | 0 | 2 | 3 | 10 | 7.5 | 0.0 | 3.2 | 5.3 | 3.8 |
| 104 | 7.40 | 7 | 0 | 3 | 6 | 16 | 10.4 | 0.0 | 4.8 | 10.7 | 6.1 |
| 102 | 7.55 | 9 | 1 | 3 | 6 | 19 | 13.4 | 1.3 | 4.8 | 10.7 | 7.3 |
| 100 | 7.70 | 15 | 2 | 6 | 7 | 30 | 22.4 | 2.6 | 9.7 | 12.5 | 11.5 |
| 98 | 7.86 | 22 | 8 | 9 | 10 | 49 | 32.8 | 10.5 | 14.5 | 17.8 | 18.8 |
| 96 | 8.02 | 27 | 11 | 10 | 12 | 60 | 40.3 | 14.5 | 16.1 | 21.4 | 23.0 |
| 94 | 8.19 | 30 | 17 | 10 | 15 | 72 | 44.8 | 22.4 | 16.1 | 26.8 | 27.6 |
| 92 | 8.37 | 35 | 20 | 17 | 19 | 91 | 52.2 | 26.3 | 27.4 | 33.9 | 34.9 |
| 90 | 8.56 | 42 | 28 | 21 | 22 | 113 | 62.7 | 36.8 | 33.9 | 39.3 | 43.3 |
| 88 | 8.75 | 43 | 34 | 26 | 24 | 127 | 64.2 | 44.7 | 41.9 | 42.8 | 48.6 |
| 86 | 8.95 | 46 | 36 | 30 | 30 | 142 | 68.7 | 47.4 | 48.4 | 53.6 | 54.4 |
| 84 | 9.17 | 48 | 44 | 33 | 37 | 162 | 71.6 | 57.9 | 53.2 | 66.1 | 62.1 |
| 82 | 9.39 | 53 | 52 | 40 | 43 | 188 | 79.1 | 68.4 | 64.5 | 76.8 | 72.0 |
| 80 | 9.62 | 55 | 58 | 47 | 46 | 206 | 82.1 | 76.3 | 75.8 | 82.1 | 78.9 |
| 78 | 9.87 | 56 | 63 | 50 | 48 | 217 | 83.6 | 82.9 | 80.6 | 85.7 | 83.1 |
| 76 | 10.13 | 61 | 73 | 55 | 52 | 241 | 91.0 | 96.0 | 88.7 | 92.8 | 92.3 |
| 74 | 10.41 | 65 | 74 | 56 | 52 | 247 | 97.0 | 97.4 | 90.3 | 92.8 | 94.6 |
| 72 | 10.69 | 66 | 76 | 57 | 53 | 252 | 98.5 | 100.0 | 91.9 | 94.6 | 96.5 |
| 70 | 11.00 | 67 | 76 | 59 | 55 | 257 | 100.0 | 100.0 | 95.2 | 98.2 | 98.5 |
| 68 | 11.32 | 67 | 76 | 61 | 56 | 260 | 100.0 | 100.0 | 198.4 | 100.0 | 99.6 |
| 66 | 11.67 | 67 | 76 | 62 | 56 | 261 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

TABLE 13.—*Number and percentage of flights made from Chicago to New York at or above different average speeds.*

| Speed (m. p. h.). | Time of flight. | Spring. | Summer. | Autumn. | Winter. | Annual. | Spring. | Summer. | Autumn. | Winter. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of flights. | | | | | Percentage of total number. | | | | |
| | *Hrs.* | | | | | | | | | | |
| 138 | 5.58 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 136 | 5.66 | 0 | 0 | 1 | 0 | 1 | 0.0 | 0.0 | 1.6 | 0.0 | 0.4 |
| 134 | 5.75 | 0 | 0 | 1 | 0 | 1 | 0.0 | 0.0 | 1.6 | 0.0 | 0.4 |
| 132 | 5.83 | 0 | 0 | 1 | 0 | 1 | 0.0 | 0.0 | 1.6 | 0.0 | 0.4 |
| 130 | 5.92 | 1 | 0 | 1 | 0 | 2 | 1.5 | 0.0 | 1.6 | 0.0 | 0.8 |
| 128 | 6.02 | 2 | 0 | 4 | 2 | 8 | 3.0 | 0.0 | 6.4 | 3.6 | 3.1 |
| 126 | 6.11 | 2 | 0 | 4 | 2 | 8 | 3.0 | 0.0 | 6.4 | 3.6 | 3.1 |
| 124 | 6.21 | 3 | 0 | 4 | 5 | 12 | 4.5 | 0.0 | 6.4 | 8.9 | 4.6 |
| 122 | 6.31 | 5 | 0 | 6 | 5 | 16 | 7.5 | 0.0 | 9.7 | 8.9 | 6.1 |
| 120 | 6.42 | 6 | 0 | 6 | 9 | 21 | 8.9 | 0.0 | 9.7 | 16.1 | 8.0 |
| 118 | 6.53 | 7 | 0 | 7 | 10 | 24 | 10.4 | 0.0 | 11.3 | 17.8 | 9.2 |
| 116 | 6.64 | 7 | 0 | 12 | 14 | 33 | 10.4 | 0.0 | 19.3 | 25.0 | 12.6 |
| 114 | 6.75 | 9 | 0 | 14 | 17 | 40 | 13.4 | 0.0 | 22.6 | 30.3 | 15.3 |
| 112 | 6.88 | 12 | 0 | 16 | 18 | 46 | 17.9 | 0.0 | 25.8 | 32.1 | 17.6 |
| 110 | 7.00 | 14 | 5 | 17 | 24 | 60 | 20.9 | 6.6 | 27.4 | 42.8 | 23.0 |
| 108 | 7.13 | 17 | 5 | 20 | 28 | 70 | 25.4 | 6.6 | 32.2 | 50.0 | 26.8 |
| 106 | 7.26 | 18 | 7 | 22 | 32 | 79 | 26.9 | 9.2 | 35.5 | 57.1 | 30.3 |
| 104 | 7.40 | 26 | 11 | 25 | 36 | 98 | 38.8 | 14.5 | 40.3 | 64.3 | 37.5 |
| 102 | 7.55 | 37 | 20 | 27 | 42 | 126 | 55.2 | 26.3 | 43.5 | 75.0 | 48.3 |
| 100 | 7.70 | 41 | 28 | 35 | 43 | 147 | 61.2 | 36.8 | 56.4 | 76.8 | 56.3 |
| 98 | 7.86 | 43 | 34 | 38 | 44 | 159 | 64.2 | 44.7 | 61.3 | 78.6 | 60.9 |
| 96 | 8.02 | 46 | 34 | 44 | 45 | 169 | 68.6 | 44.7 | 71.0 | 80.3 | 64.7 |
| 94 | 8.19 | 51 | 36 | 47 | 47 | 181 | 76.1 | 47.4 | 75.8 | 83.9 | 69.3 |
| 92 | 8.37 | 54 | 41 | 49 | 50 | 194 | 80.6 | 53.9 | 79.0 | 89.3 | 74.3 |
| 90 | 8.56 | 56 | 48 | 54 | 54 | 212 | 83.6 | 63.1 | 87.1 | 96.4 | 81.2 |
| 88 | 8.75 | 59 | 52 | 55 | 55 | 221 | 88.0 | 68.4 | 88.7 | 98.2 | 84.7 |
| 86 | 8.95 | 60 | 58 | 55 | 55 | 228 | 89.5 | 76.3 | 88.7 | 98.2 | 87.3 |
| 84 | 9.17 | 62 | 63 | 58 | 56 | 239 | 92.5 | 82.9 | 93.5 | 100.0 | 91.6 |
| 82 | 9.39 | 63 | 65 | 59 | 56 | 243 | 94.0 | 85.5 | 95.2 | 100.0 | 93.1 |
| 80 | 9.62 | 64 | 67 | 60 | 56 | 247 | 95.5 | 88.1 | 96.8 | 100.0 | 94.6 |
| 78 | 9.87 | 65 | 69 | 62 | 56 | 252 | 97.0 | 90.8 | 100.0 | 100.0 | 96.5 |
| 76 | 10.13 | 67 | 69 | 62 | 56 | 254 | 100.0 | 90.8 | 100.0 | 100.0 | 97.3 |
| 74 | 10.41 | 67 | 73 | 62 | 56 | 258 | 100.0 | 96.0 | 100.0 | 100.0 | 98.8 |
| 72 | 10.69 | 67 | 74 | 62 | 56 | 259 | 100.0 | 97.4 | 100.0 | 100.0 | 99.2 |
| 70 | 11.00 | 67 | 75 | 62 | 56 | 260 | 100.0 | 98.7 | 100.0 | 100.0 | 99.6 |
| 68 | 11.32 | 67 | 75 | 62 | 56 | 260 | 100.0 | 98.7 | 100.0 | 100.0 | 99.6 |
| 66 | 11.67 | 67 | 75 | 62 | 56 | 269 | 100.0 | 98.7 | 100.0 | 100.0 | 99.6 |
| 64 | 12.03 | 67 | 76 | 62 | 56 | 261 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

The figures in the bottom line of columns 3 to 7 inclusive in each table represent the total number of flights made. The percentage of delayed flights for the schedules given in the first two columns may be readily obtained by subtracting from 100 the values in the five columns at the right of each table.

The seasonal variation is well shown by these data. It is of course greatest for the highest speeds since the latter result from strong assisting winds, and these occur most frequently in the winter half of the year. From an operation standpoint, as already stated, we are most interested in speeds that can be maintained a large part of the time and at these lower speeds, 75 to 80 miles per hour, the seasonal variation is small. This being the case, it seems scarcely necessary to determine for each season, the allowance that should be made for head winds, more particularly since in any aviation enterprise involving day to day flight bids must be made and contracts placed on a yearly basis. Considering then only the annual percentages we have plotted these, i. e., the figures in the last columns of Tables 12 and 13, in figures 2 and 3 respectively. Ordinates represent the percentages of flights that were made at or above the speeds indicated by abscissae.

The curve in figure 2 shows that approximately 50 per cent of the flights were made at a speed of 86 m. p. h. or more, which is the normal cruising speed less the resultant wind, $0.85S-R$; and about 30 per cent were made at or above the normal cruising speed, 93 m. p. h. These latter represent flights in which material assistance was realized from easterly winds. The part of the curve to the right of 93 m. p. h. indicates flights whose speed was cut down by westerly winds. In both cases the exact relation of the plane's airspeed to the resulting ground speed must be chosen somewhat arbitrarily, since, as already stated, with tail winds pilots may ease up on the motor, and with head winds the airplane's cruising speed may be increased in proportion to the strength of those winds, until its limit has been reached, viz, $S=110$ m. p. h. Most interest, of course, lies in the upper part of the curve, that showing a high percentage. If arrival on or ahead of schedule 95 per cent of the time is taken as a satisfactory operating performance, inspection of the curve indicates that this would be realized, in the case of the Mail planes, with a schedule based on a speed of 74 m. p. h. This means, if we still assume $S=110$, that 5 per cent of the time there occur head winds exceeding a speed whose value we can readily determine from aerological observations.

The kite and balloon records which have been used in the early part of this paper have been examined for the present purpose also and as a result it is found that at an altitude of 1,500 feet a wind with a west component of 36 m. p. h. or more occurs 5.2 per cent of the time. If this value, 36, were placed at the bottom of the figure under the ground speed of 74, and other wind speeds were properly placed with reference thereto, the zero point would fall under 110, from which it is evident that the latter value represents very closely the high cruising speed of the planes, as originally deduced from the assumption that the normal cruising speed, 93, is 85 per cent of the high cruising speed. It should be distinctly borne in mind that with lower wind speeds the speed of the planes is likewise lowered and that therefore the wind scale does not fit the curve except for high winds which it is necessary to overcome by letting out the motor to its limit. For lower wind speeds the zero of the scale would shift successively to the right, until it reached 93 m. p. h. for no wind. With easterly, i. e., tail winds, the zero would again shift slightly to the right, the amount depending upon the strength of those winds, and the wind scale would increase in reverse direction, i. e., from right to left. With a shifting zero it would be difficult to evaluate the wind effect for the lower speeds and fortunately it is not necessary to do so, since interest is centered almost entirely in a high percentage of schedule maintenance. It is believed worth while, however, to endeavor to justify the assumption of a shifting zero, and for this purpose the kite and balloon records already used in this paper have been examined with a view to determining what percentage have a west component, i. e., are from any direction between N 1° W and S 1° W, regardless of speed. These records give the following results:

| | Percentage of winds with west components. |
|---|---|
| Drexel, Nebr. | 65 |
| Royal Center, Ind. | 73 |
| Group 1 | 73 |
| Group 2 | 68 |
| Mean | 70 |

The remaining 30 per cent include calms and winds with an east component. It has been stated that with no wind the zero of the scale at the bottom of figure 2 would fall under the ground speed of 93. If this be so, then the curve at the abscissa of 93 should have an ordinate of 30. In reality it passes through 31—an agreement which sufficiently justifies the assumption as to the shifting zero.

In confirmation of the statement that with very high winds advantage is taken of the plane's maximum speed of 110 m. p. h. it may be added that kite and balloon records show that winds with a west component of 42 m. p. h. occur 2.0 per cent of the time, whereas the curve in figure 2 indicates 0.4 per cent. Under the conditions

specified, therefore, viz., that the normal cruising speed, 93 m. p. h., is 85 per cent of the maximum that can be maintained over the whole course and that allowance is made for winds with a west component of 36 m. p. h. a flight speed of 74 miles per hour or better can be guaranteed 95 per cent of the time.

The curve in figure 3 furnishes information for eastward flight similar to that in figure 2 for westward flight. The significance of the wind effect is well brought out by a comparison of the two figures. Figure 3 indicates that approximately 50 per cent of the flights were made at a higher speed than 100 m. p. h. and that in about 70 per cent the normal cruising speed, 93 m. p. h., was exceeded. The part of the curve to the left of 93 represents flights in which material assistance was experienced from tail, i. e., westerly winds; that to the right, those flights whose speed was cut down by easterly winds. In the upper part of the curve we find that 95 per cent of the flights were made at or above a speed of 80 m. p. h. An examination of kite and balloon records shows that

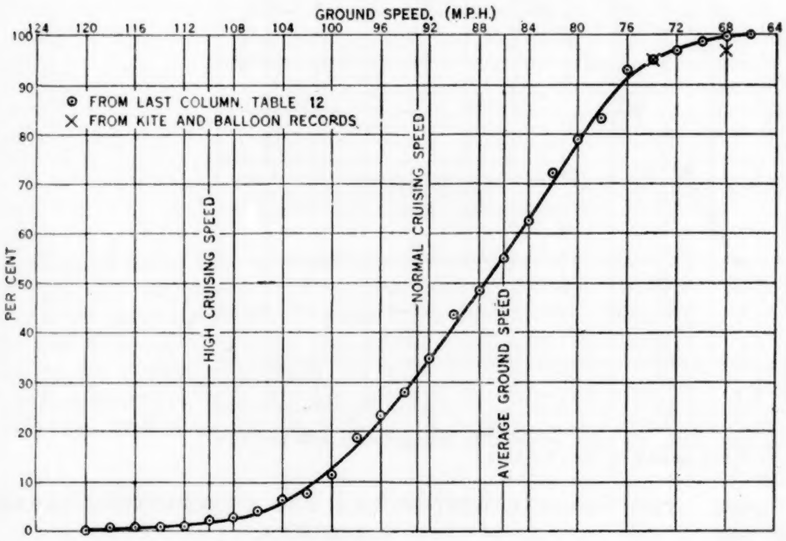


FIG. 2. Percentage of trips made from New York to Chicago, 770 miles, at different average speeds with airplanes whose normal cruising speed is 93 miles per hour.

winds with an east component of 20 m. p. h. or more occur 4.9 per cent of the time. If this value were placed under 80 and the scale extended to its zero, the latter would fall under 100 instead of 110 as in figure 2. This is not surprising; it means simply that in eastward flight it is seldom necessary to bring into play the reserve power of the motor, or at any rate an appreciable part of it. As in figure 2, a second point on the curve has been compared with the kite and balloon records. The latter give 2.4 per cent as the frequency of winds having an east component of 27 m. p. h., and the curve at this point indicates about 1 per cent.

### APPLICATION TO AIRCRAFT OF DIFFERENT SPEEDS.

Having determined what may be called the "critical" wind speed for a 95 per cent schedule maintenance, we can now apply the results of this study to aircraft of any speed. At the present time the normal cruising speed of aircraft, including lighter than air, ranges approximately between 50 and 150 m. p. h. Still assuming that this normal cruising speed is 85 per cent of the maximum speed that can be maintained, we can quickly compute the latter and from it deduct the wind for which allowance must be made, viz., 36 m. p. h. for westward, and 20 m. p. h. for eastward flight. This value divided into 770, the length of the course, gives the schedule in hours that can be kept 95 per cent of the time. The results are shown in Table 14 and in figures 4 and 5.

TABLE 14.—*Time schedules for flights between New York and Chicago.*

| Normal cruising speed (0.85S). | High cruising speed (S). | Westward flights. | | Eastward flights. | |
|---|---|---|---|---|---|
| | | Allowance for wind (S−36). | Time schedule. | Allowance for wind (S−20). | Time schedule. |
| | | | *Hours.* | | *Hours.* |
| 50 | 59 | 23 | 33.48 | 39 | 19.74 |
| 60 | 71 | 35 | 22.00 | 51 | 15.10 |
| 70 | 82 | 46 | 16.74 | 62 | 12.42 |
| 80 | 94 | 58 | 13.28 | 74 | 10.41 |
| 90 | 106 | 70 | 11.00 | 86 | 8.95 |
| 93 | 109 | 73 | 10.55 | 89 | 8.65 |
| 100 | 118 | 82 | 9.39 | 98 | 7.86 |
| 110 | 129 | 93 | 8.28 | 109 | 7.06 |
| 120 | 141 | 105 | 7.33 | 121 | 6.36 |
| 130 | 153 | 117 | 6.58 | 133 | 5.79 |
| 140 | 165 | 129 | 5.97 | 145 | 5.31 |
| 150 | 176 | 140 | 5.50 | 156 | 4.93 |

An inspection of the figures brings out very clearly the difficulties of the westward trip for low-speed aircraft. With a normal cruising speed of 50 m. p. h. almost twice as much time would be required as for the eastward trip. The importance of the wind factor diminishes of course with the higher cruising speeds, and with values of the latter above 100 m. p. h. the difference in the two directions is not large, amounting to about $1\frac{1}{2}$ hours at 100 m. p. h. and slightly more than half an hour at 150 m. p. h. In all cases we are assuming that against high head winds the speed of the aircraft can be increased from 0.85S to S.

In the foregoing discussion no allowance has been made for service stops or for change in time. We have considered only the actual time during which the planes were in the air. As stated in the report, quoted in part at the begining of this paper, the Air Mail Service at present consists of a relay advance of mail from New York to Cleveland, Cleveland to Chicago, and so on. In addition, 20-minute service stops are made at Bellefonte, Pa., and at Bryan, Ohio. The length of time required for stops in commercial aviation would vary according to the character of the service rendered. If this were for mail, express or passenger transportation the stops would probably be short, but if for freight they would necessarily be somewhat longer. Probably one stop would be sufficient—that at Cleveland. As a working basis we can assume that it would be one hour. It is to be noted that the relative importance of this, since it is a constant, increases with the higher speed aircraft.

In a commercial sense the wind factor is offset—to a considerable extent for low cruising speeds and completely so for high—by the change in time. For instance, Table 14 shows that the schedule for a normal cruising speed of 90 m. p. h. is 11 hours from New York to Chicago and practically 9 hours in the opposite direction. Including one hour for service stops, these become 12 and 10 hours respectively. By the clock, however, (and this is the important consideration in business) the trip is made in each direction in 11 hours. Thus, mail leaving the Terminal Fields at each city at 8 p. m. arrives at the other on the following morning at 7 a. m. Applying the change in time to the values in columns 4 and 6 of Table 14 and making an allowance of 1 hour for stops, we have the revised schedule given in Table 15 and in figure 6.[6]

[6] Commercial enterprise would have to add to this the time required to reach the Terminal Fields from the center of town, at both terminals, in making comparison with rail schedules.

TABLE 15.—*Time schedules for flights between New York and Chicago Terminal Landing Fields, including 1 hour for stops and allowing for change in time.*

| Normal cruising speed. | Time in hours. | |
|---|---|---|
| | New York to Chicago. | Chicago to New York. |
| 50 | 33.48 | 21.74 |
| 60 | 22.00 | 17.10 |
| 70 | 16.74 | 14.42 |
| 80 | 13.28 | 12.41 |
| 90 | 11.00 | 10.95 |
| 100 | 9.39 | 9.86 |
| 110 | 8.28 | 9.06 |
| 120 | 7.33 | 8.36 |
| 130 | 6.58 | 7.79 |
| 140 | 5.97 | 7.31 |
| 150 | 5.50 | 6.93 |

all the days in the year and that 95 per cent of those flights are made in accordance with the schedules shown in figures 4 and 5, we have 90.2 as the final percentage of schedule maintenance throughout the year. It is to be noted in figures 2 and 3 that the amount of delay in those flights, 5 per cent of the total, that would fail to arrive within the schedule, is not large, and it is worthy of remark that other means of transportation, rail, steamship, motor truck, etc., are themselves subject to occasional delays. Finally, if the number of complete failures can be reduced by overcoming the effects of unfavorable weather (again not including the wind factor), the normal percentage of schedule maintenance here shown to be 90.2, will be increased accordingly.

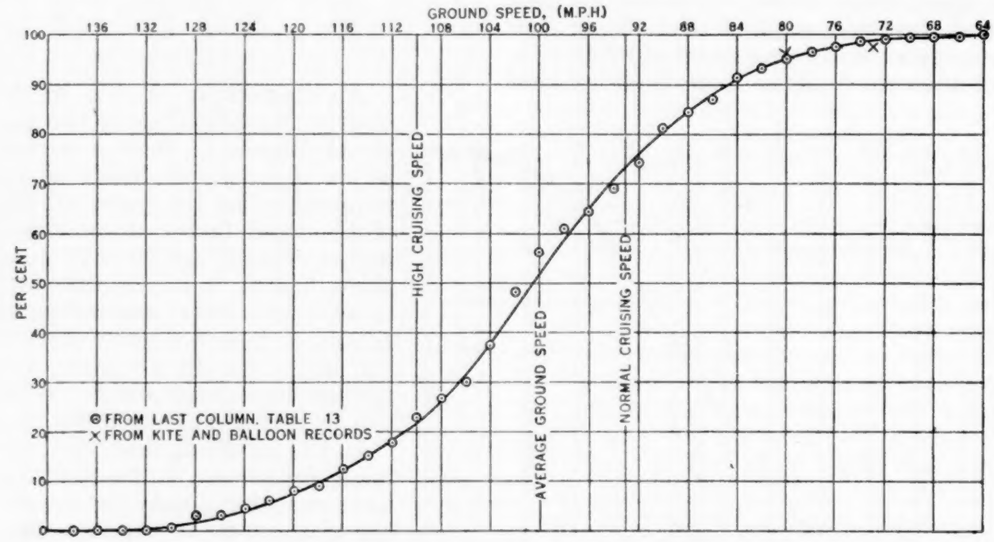


FIG. 3. Percentage of trips made from Chicago to New York, 770 miles, at different average speeds with airplanes whose normal cruising speed is 93 miles per hour.

From the table and curves it is apparent that, with aircraft of high cruising speed, *advantage lies with the westward trip, so far as commercial service is concerned.*

It must be distinctly understood that the data given in figures 2 to 5 and in Tables 14 and 15 have reference solely to those days during the year on which flights were completed in both directions. As shown in Table 9, these days constituted 85.3 per cent of the total. Failures on 14.7 per cent of the days were due to various causes, such as bad weather (not including high winds), motor trouble, necessity for repairs to the plane en route, etc. As has already been indicated some of these causes of failure will become nonexistent with improvement in equipment and in facilities for handling aircraft at landing fields. It has also been shown that the weather was no more unfavorable on some days when failures were recorded than on others when flights were successful. Finally, in a few cases flights were completed in one direction only. If these latter were included, the percentage would become 86.3 for the westward, and 87.2 for the eastward trip. On the basis of the points above briefly reviewed we have previously stated that a conservative estimate would place the unavoidable percentage of failures to complete flights at no more than 5. Assuming, then, that flights are made on 95 per cent of

### THE GENERAL WIND CURVE FOR DETERMINING VARIOUS SCHEDULES.

Figures 4 to 6, inclusive, represent the application of the preceding analysis to a particular percentage performance of aircraft over a definite route, that between New York and Chicago. It may be desired to determine schedules based on other performances, greater or less than 90 per cent and for different lengths of routes. For this purpose figure 7 has been prepared to show the number of times during a normal year that east or west winds of varying strength occur. The following example will indicate how this curve may be applied:

An aircraft with a normal cruising speed of 80 m. p. h. and a high cruising speed of 90 m. p. h. is to be operated over a route 1,000 miles in length. It is desired to determine what percentage of the trips will be made in a flying time of 13 hours or less. (To compare with train schedules, the length of time to get from the terminal cities to the terminal airports, time consumed in any stops en route, and the change in clock time going east or west must of course be added to the flying time.) From figure 7 we read that a wind from the west of 13 m. p. h., or more, occurs 30 per cent of the time. Assuming that the aircraft maintains its high cruising speed of 90 m. p. h. over the entire distance, the resultant

ground speed will therefore be 77 m. p. h., or less, for 30 per cent of the westbound trips. Dividing the distance traveled, 1,000 miles, by this ground speed the flying time is found to be just 13 hours. Hence it is determined that such an aircraft could maintain a 13-hour schedule 70 per cent of the time. The exact

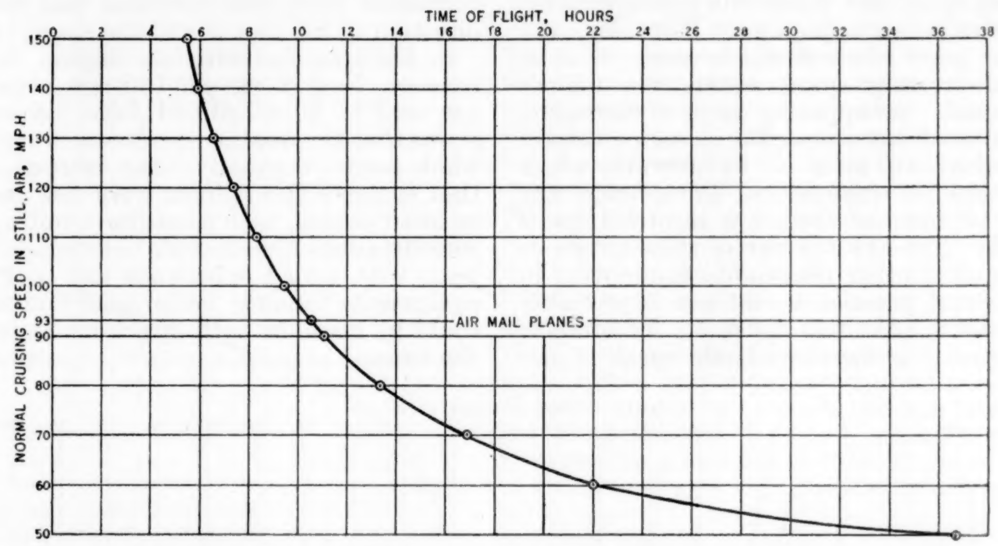


FIG. 4. Curve showing schedules for flight from New York to Chicago, 770 miles, that can be guaranteed 90 per cent of the time for aircraft of different normal cruising speeds. Allowance made for head and cross winds; no allowance made for service stops or change in time.

amount of delay due to wind which would be encountered during any proportion of the remaining 30 per cent of the trips may be similarly read from the curve. During 30 per cent of the trips the curve indicates that there would be a favoring wind on west-bound flights. The exact amount which the airspeed of the aircraft can be reduced, and still arrive within 13 hours, can be read

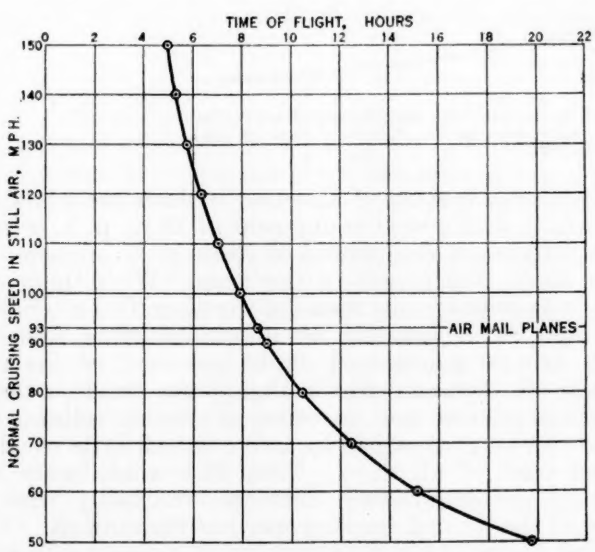


FIG. 5. Curve showing schedules for flight from Chicago to New York, 770 miles, that can be guaranteed 90 per cent of the time for aircraft of different normal cruising speeds. Allowance made for head and cross winds; no allowance made for service stops or change in time.

from the curve, thereby determining the amount of fuel which may be saved by running the engines throttled. Similar calculations may be made for east-bound flights and for aircraft of different cruising speeds, or for different lengths of routes.

Figure 7 brings out strikingly several features already referred to in the text, of which three are of particular interest:

(*a*) The percentage of time abnormally strong east or west winds occur, as deduced from (1) kite and balloon records, (2) westbound flights, and (3) eastbound flights, agrees very closely.

(*b*) The percentage of time west winds of moderate strength occur, as deduced from westbound flights, is consistently lower by two or three miles than that deduced from eastbound flights. This is exactly what would be anticipated, as explained in the text following Table 2. The point where the wind curve passes from west to east is especially interesting; kite and balloon records show this to be at 70 per cent (see text following Tables 12 and 13); westbound flights are able to avoid west winds a small fraction of the time by flying at a lower altitude and thus pass from the region of west winds to east at the point 67 per cent (see Figure 2); eastbound flights prolong the region of westbound, favoring winds slightly by flying at a higher altitude and thus pass from west to east winds at 73 per cent (see figure 3).

(*c*) Finally, the percentage of winds determined from kite and balloon records is in almost every instance slightly greater than that deduced from either east or westbound flights. This is exactly what would be expected since the flying records give the resultant effect of the winds occurring along the route during all the hours of the flight, whereas the kite and balloon records show only the winds over a fixed point at the time of observations, not what may be denoted as the "integrated" wind effect.

It should be noted that figures 2 and 3 showing the ground speed of Mail planes on west and east flights, respectively, can not be used directly to give the wind percentages of figure 7 until some assumption is made as to the actual average airspeed maintained by the planes when flying against a strong opposing wind or with a strong favorable wind. This actual airspeed will vary, as already explained, from the highest cruising speed which the plane can maintain, down to a speed somewhat less than the normal cruising speed when flying with an especially favorable wind. The determination of this actual average airspeed, within the limits mentioned, for varying wind conditions must be somewhat empirical, as no record of the actual airspeed is kept by the Air Mail, nor is the airspeed of a plane likely to be maintained constant throughout an entire flight.

The evaluation of this "shifting zero" from the normal cruising airspeed may, however, be made from a knowledge of the practice of pilots when flying a route with favoring or opposing winds. In the present instance a smooth curve has been drawn (not reproduced, however, in the published figures) on figures 2 and 3 paralleling the normal cruising speed line where the winds encountered are only a few miles opposing or favorable, and passing through the point where no winds occur—that is, where the normal cruising speed equals the plane's resultant ground speed. As opposing winds of increasing strength are encountered, the airspeed is increased toward the high cruising speed, 110 m. p. h.; as favorable winds of increasing strength are encountered the average airspeed is assumed to decrease toward a throttled speed of about 85 m. p. h. The exact choice of these airspeeds is not important, as any other reasonable assumption in fair accord with actual practice would not appreciably change the wind values shown in figure 7. The important fact about figure 7 is the remarkable check it presents between westbound and eastbound flights and the results of kite and balloon records.

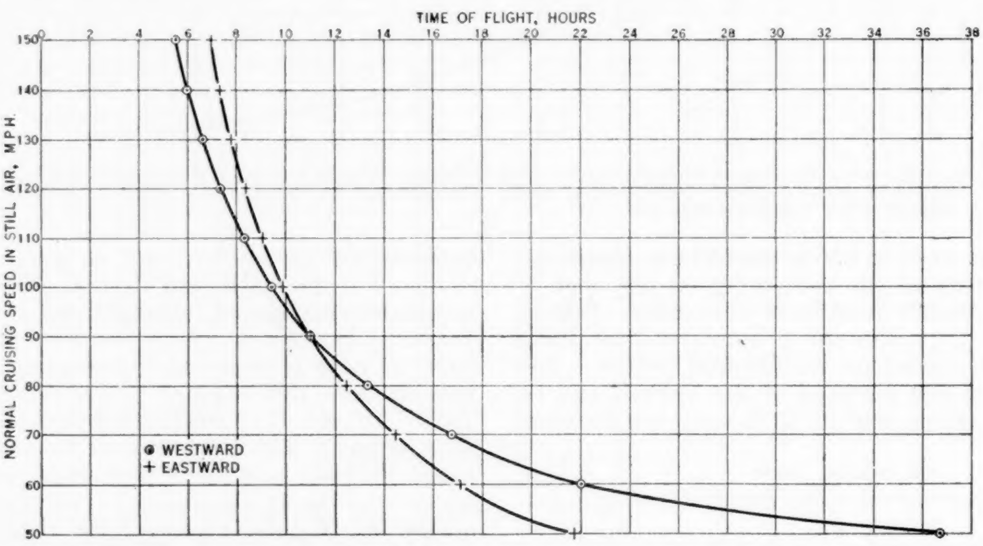


FIG. 6. Curves showing schedules for westward and eastward flight between New York and Chicago, 770 miles, that can be guaranteed 90 per cent of the time for aircraft of different normal cruising speeds. Allowance made for head and cross winds; for 1 hour service stops each way; and for change in time.

### SUMMARY AND CONCLUSIONS.

1. From an analysis of the Air Mail records it has been found that the wind factor for the route between New York and San Francisco is approximately 7 miles per hour from the west.

2. A more detailed study of the New York to Chicago part of the route gives almost exactly the same wind factor as for the entire transcontinental route.

3. The altitude of flight varies with different conditions of wind and weather, but on the average may be taken as 1,500 feet above the surface. On this assumption aerological observations that have been made by means of kites and pilot balloons have been summarized, and these indicate a resultant wind very closely agreeing with the wind factor determined from the flight records themselves, the difference being less than 1 mile per hour. This agreement is close, not only in the annual means, but is almost equally good in those for the four seasons.

4. It follows from the three preceding paragraphs (*a*) that regular flights in both directions between two points, for a period of one year, furnish reliable data for the determination of the wind factor, and (*b*) that this factor can be known before any flights are made, if free-air wind data from observations with kites and balloons are available. These data make possible the computation of resultant winds, whose average effect on flights can be readily calculated from their direction and speed and from the direction of the course and the speed of the aircraft.

5. Failures to complete flights in both directions between New York and Chicago occurred on about 15 per cent of all scheduled days. A study for the year shows that the weather conditions were unfavorable somewhat more frequently than normal, and furthermore that some of the failures were not due to weather, but to other causes, such as engine trouble, etc. From these considerations it seems safe to conclude that, in an average year, with added experience and with improvements in equipment, landing fields and communication, flights could be made in both directions at least 95 per cent of the time.

6. An examination of kite and balloon records shows that winds with a west component of 36 m. p. h. or more and with an east component of 20 m. p. h. or more each occur about 5 per cent of the time. With these data and the known cruising speed of the aircraft, both normal and high, it is possible to determine time schedules which can be guaranteed on 95 per cent of the total number of days on which flights are made. Hence, including failures due to other causes, it follows that flights can be guaranteed to arrive on schedule on about 90 per cent of all days. Since the wind factor is a constant, its importance decreases markedly with increase in the normal cruising speed of the aircraft. With the cruising speed less than 80 m. p. h. no great advantage can be claimed so far as this route is concerned, over the excellent railroad service now maintained. The wind handicap can rarely, if ever, be evaded by flying around high or low pressure areas in order to gain assistance from favoring winds, since these areas usually cover a wide territory, and the gain from winds would be more than offset by the greater distance flown, not to mention the disadvantages of unfamiliarity with the route, lack of landing fields, etc.

The results of this analysis, although based entirely on day-time flights, apply equally well to night flying. There is a small diurnal variation in wind speed at the surface, with a minimum at night, but this variation ceases at a comparatively low altitude and at greater heights is opposite in phase. At the most, however, its interest in aviation is purely academic since it amounts to only a small fraction of the total wind except on comparatively quiet days. In stormy weather no variation at all is apparent.

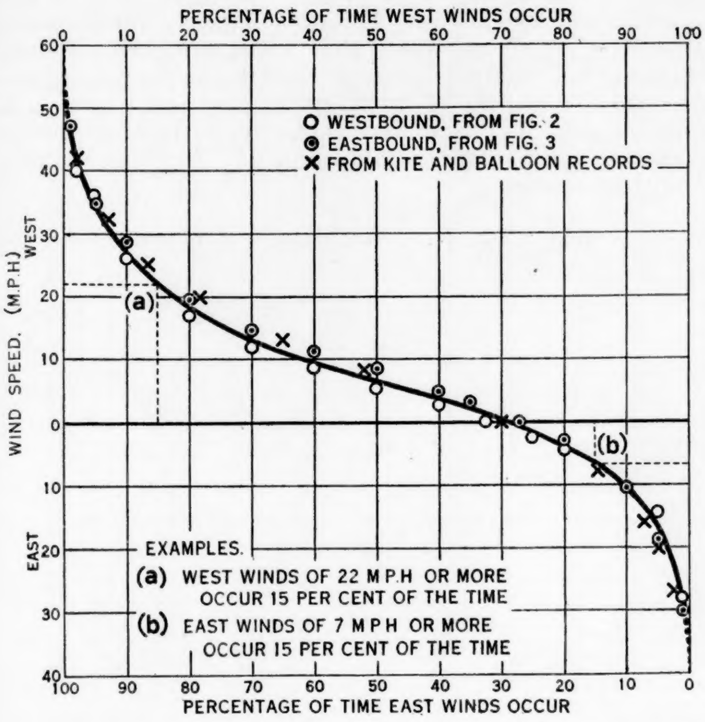


FIG. 7. Annual percentage occurrence of east and west winds of different speeds along the New York-Chicago route.

7. The results given in this paper are strictly applicable only to the Air Mail route between New York and San Francisco, and particularly to that portion of it between New York and Chicago. It has been shown that for that route the kite and balloon records make possible the determination of safe operating flight schedules. For any other route free-air observations made in that region should be used. The resultant wind for the year, and for the seasons also if desired, should be resolved into components parallel and perpendicular to the course. With these data and the cruising speed of the aircraft and with proper allowance for angle of drift the average wind factor can be easily computed. In determining flight schedules that can be guaranteed any required percentage of the time, e. g., 95 per cent, the individual wind records should be examined to find out the speed of head winds, including the equivalent component effect of cross winds, that occurs the maximum percentage of the time delayed trips are permissible, e. g., in the present case 5 per cent. Thus, if the route is from north to south and vice versa, the components into which the winds should be resolved are north and south instead of east and west as in the present paper.

8. The importance of meteorology to aviation is generally recognized. This recognition has as its primary basis the need for information as to weather conditions, current and predicted. The present study of the Air Mail records shows that the usefulness of meteorology is not thus limited, but that past data have almost equal value. In order to serve effectively both purposes there is urgent need for material extension in aerological investigations, comprising a network of stations well distributed and covering all parts of the country.

## WIND DIRECTIONS AND THE ORIENTATION OF SCHOOLHOUSES.

By ROSCOE NUNN, Meteorologist.

[Weather Bureau, Nashville, Tenn., April 18, 1923.]

The purpose of this paper is to furnish information that may be useful in connection with the orientation, lighting, and ventilation of schoolhouses in the Southern States.

There is an opinion, more or less prevalent, that it is essential in the Southern States to have the windows of schoolhouses on the south side, as a rule, in order to catch the prevailing breezes in the warm season. The question has arisen whether south winds prevail to such an extent as to justify such a rule, and whether the most advantageous arrangements for lighting and sunning schoolrooms should be sacrificed to any considerable degree in order to secure openings on the south.

At the suggestion of Dr. F. B. Dresslar, of the department of health and sanitation, George Peabody College for Teachers, and special agent of the United States Bureau of Education, the writer undertook to gather statistics that would show the prevailing winds at various Weather Bureau stations for the hours 8 a. m. to 4 p. m., in the months of April, May, June, September, and October, covering the warmest part of the school year. Dr. Dresslar made an experimental investigation of the effects of various orientations of a model schoolhouse on the lighting and sunning of rooms, which showed that windows on the west or east are most advantageous.

Do southerly winds predominate to such an extent as to make it really important to have the windows of schoolrooms on the south side? Or, are the prevalence of southerly winds and the advantages to be derived from them so slight as to be negligible when weighed against the advantages of better lighting and sunning of rooms secured with west or east windows?

A condensed table of the wind-direction statistics obtained is given herewith. The table shows the prevailing direction from which the wind comes during the hours given. When we say the "prevailing" direction is, for instance, southwest, we mean that the wind came from the southwest oftener than from any other of eight directions. This does not mean that it was from the southwest most of the time; in fact, a prevailing wind, in the sense here used, might show only slightly more than one-eighth of 100 per cent of the whole, because the other seven directions might have been represented by almost one-eighth each. For example: the most frequent wind direction at Nashville, based upon records of many years, is northwest, but the general average percentage of times

that the hourly prevailing direction was from the northwest is only 20; while other directions are represented by 10, 12, 13, etc., the lowest, 7 per cent, being east.

At Weather Bureau stations the wind direction is automatically recorded each minute; but, in tabulating the data, the direction having the greatest percentage of time in any hour is given credit for that full hour, while all other directions represented get no credit. This method, evidently, will balance out fairly for each direction in the course of time; so that, if records for a number of years are used, the time credited to each direction will be approximately correct. The table, therefore, may be accepted as a fairly accurate, general presentation of the facts.

In considering the data in the table, it should be remembered that some stations have a much more pronounced prevailing direction than others; for example, Nashville has wind prevailing from the northwest during the hours given in April, with an average of 49 per cent, while New Orleans has southeast, with 68 per cent.

The last column of the table gives the direction or directions found most often in the preceding columns for each station and may be considered as presenting the prevailing direction for the whole period for the hours 8 a. m. to 4 p. m. of April, May, June, September, and October. But the question, which of these months are most important in this connection (ventilation of school buildings) must be considered, for it may be that the warmer months of May and June should be given greater weight, while the cooler months of April and October should be given less weight. It would be wise to consider the whole record at near-by Weather Bureau stations, with an eye to the most important portions of the warm-weather period.

The records show a rather mixed distribution of air movement over the Southern States, due principally to local topography and the varied conditions of exposure of wind vanes. But there are also regional characteristics of wind direction, due to geographical differences, the paths of general storms, and the distribution of mean temperature and mean atmospheric pressure.

Topographical effect is shown clearly at Fort Smith, Ark., where the wind rarely blows for any length of time from any direction other than east, due to the trend of the valley in which the wind vane is located. This is the most conspicuous case of the kind among Weather Bureau stations in the Southern States, but doubtless other similar situations exist. In the highland and mountain districts of Tennessee, Georgia, the Carolinas, and Virginia, the wind directions are evidently affected to some extent by the broken character of the land surface, ridges, and valleys; otherwise, it is difficult to account for some of the characteristics of the records at the several stations. The westerly component is prominent at Nashville, Knoxville, Atlanta, Asheville, Wytheville, and Lynchburg.

The suggested regional distribution may be grouped as, (1) the States of Arkansas, Oklahoma, Texas, Louisiana, southern Mississippi, and western Alabama, where southerly winds, especially south and southeast, predominate decidedly throughout the period; (2) the eastern half (roughly) of the States of Virginia, North Carolina, South Carolina, Georgia, southern Alabama, and all of Florida, where the prevailing winds in spring and early summer are from the southwest and in September and October from the northeast; (3), the remaining portions of the Southern States, embracing Tennessee and the highlands and mountainous portions of Georgia, the Carolinas, and Virginia, where the westerly component (southwest, west, and northwest) predominates.

Means or averages of the data in the table, covering the whole area, are probably of little value. It is difficult to compute a correct mean from these data, as the sections of the area are disproportionately represented. However, it may be stated that, considering all the data in the table, we find that southwest is the most frequent direction recorded. This is followed by south, which is considerably less frequent; then by northwest, northeast, and southeast, of equal frequency, but considerably less than south.

*Prevailing winds (8 a. m. to 4 p. m.) for the months given.*

| Stations. | April. | May. | June. | September. | October. | Period. |
|---|---|---|---|---|---|---|
| Alabama: | | | | | | |
| Anniston | nw. | nw. | n. | se. | se. | se. and nw. |
| Birmingham | s. | s. | s. | s. | se. | s. |
| Montgomery [1] | se. | sw. | sw. | e. | e. | sw. and e. |
| Arkansas: | | | | | | |
| Bentonville | s. | s. | s. | s. | s. | s. |
| Fort Smith | e. | e. | e. | e. | e. | e. |
| Little Rock | s. | s. | s. | ne. | s. | s. |
| Florida: | | | | | | |
| Jacksonville | sw. | sw. | sw. | ne. | ne. | sw. |
| Pensacola | se. | s. | s. | s. | se. | s. |
| Tampa | ne. | sw. | sw. | ne. | ne. | ne. |
| Georgia: | | | | | | |
| Atlanta | nw. | nw. | w. | e. | e. | nw. and e. |
| Augusta | nw | nw. | sw. | ne. | ne. | ne. and nw |
| Macon | nw. | ne. | sw. | ne. | ne. | ne. |
| Savannah | sw. | sw. | w. | ne. | ne. | ne. and sw. |
| Thomasville | sw. | sw. | sw. | ne. | ne. | sw. |
| Louisiana: | | | | | | |
| New Orleans | se. | se. | se. | ne. | ne. | se. |
| Shreveport [1] | s. | se. | s. | se. | se. | se. |
| Mississippi: | | | | | | |
| Vicksburg | sw. | sw. | sw. | nw. | nw. | sw. |
| North Carolina: | | | | | | |
| Asheville [1] | nw. | nw. | nw. | nw. | nw. | nw. |
| Charlotte | sw. | sw. | sw. | ne. | ne. | sw. |
| Raleigh | sw. | sw. | sw. | ne. | ne. | sw. |
| Wilmington | sw. | sw. | sw. | ne. | ne. | sw. |
| Oklahoma: | | | | | | |
| Oklahoma | s. | s. | s. | s. | s. | s. |
| South Carolina: | | | | | | |
| Charleston | s. | s. | s. | ne. | n. | s. |
| Greenville | sw. | sw. | w. | ne. | e. | sw. |
| Tennessee: | | | | | | |
| Chattanooga [1] | s. | sw. | sw. | ne. | ne. | sw. and ne |
| Knoxville [1] | sw. | sw. | sw. | ne. | ne. | sw. |
| Memphis | sw. | sw. | sw. | sw. | sw. | sw. |
| Nashville | nw. | sw. | sw. | nw. | nw. | nw. |
| Texas: | | | | | | |
| Abilene | sw. | sw. | se. | sw. | sw. | sw. |
| Amarillo | sw. | s. | s. | s. | s. | s. |
| Dallas | s. | s. | s. | s. | se. | s. |
| Fort Worth | s. | s. | s. | s. | s. | s. |
| Galveston | se. | se. | se. | se. | se. | se. |
| Houston | se. | se. | s. | se. | se. | se. |
| San Antonio | se. | se. | se. | se. | se. | se. |
| Virginia: | | | | | | |
| Lynchburg | nw. | sw. | sw. | ne. | nw. | nw. and sw. |
| Norfolk | nw. | ne. | ne. | ne. | ne. | ne. |
| Richmond | sw. | sw. | ne. | ne. | sw. | sw. |
| Wytheville | w. | w. | w. | e. | w. | w. |

[1] Hourly data not available; therefore the monthly prevailing direction has been used.

If we take the States east of the Mississippi River, we find southwest winds distinctly predominating, followed by northeast and northwest. Taking Arkansas, Oklahoma, and Texas, we find south strongly prevailing, with southeast next, and but little from any other direction.

By months, considering the whole area, we find that southwest winds prevail in April, May, and June, and northeast in September and October; but south is a pretty strong second.

But these groupings and averages are considered of no great value for guidance in the orientation of a schoolhouse in any particular locality. They do indicate that there is no strong prevalence of south winds except in Arkansas, Oklahoma, Texas, and Louisiana. Emphasis should be placed upon the advisability of making as

thorough investigation as practicable of conditions in each locality in the preliminary plans for school buildings, and this generally can be done through near-by Weather Bureau stations.

It is obvious that south windows would catch the breezes from the southeast, south, and southwest; west windows would catch them from the southwest, west, and northwest. But west windows, it seems, are decidedly preferable from the standpoints of light and sanitation. Therefore, where the prevalence of south winds is very strong, as in the Southern States west of the Mississippi River, a choice of west or south windows may be difficult to make; but in the States east of the Mississippi River, generally speaking, it would seem that any sacrifice of other features to secure south breezes would be a mistake.

## RADIO REPORTS GIVE TIMELY NOTICE OF RAINS IN CALIFORNIA.

By GEO. H. WILLSON, Meteorologist.

[Weather Bureau, San Francisco, Calif., April 26, 1923.]

From radio reports received twice daily at San Francisco from vessels in the North Pacific ocean the presence of storms and their approximate location is in nearly all instances known several days before their approach is indicated at coast stations, but the reports are generally so scattered that the direction in which the storm is moving and its rate of progression are too indefinite for use as a basis for a forecast. To make a definite forecast, that is, one that would be of any practical value, it is necessary to have sufficient data to know what the pressure distribution over the Canadian northwest, Rocky Mountain States and off the California coast will be about the time the storm is expected to reach the coast.

In general, a storm moving east or southeast from the North Pacific will not give rain in California unless its eastward movement is deflected southward by an area of high pressure over Alaska or British Columbia. When this is the case, the storm will, in nearly all cases, when about 500 or 1000 miles off the coast, develop a trough extending southward to about the latitude of San Francisco, and the center will enter the coast south of the Columbia river.

These conditions prevailed during the last week of March, 1923, and the writer was enabled to make a forecast of the approach of a storm several days in advance of its appearance on the coast. Subsequent comment by both the press and the public showed a deep appreciation of the work.

The storm which reached the Pacific coast on Friday night (March 30), and broke the long drought in California was first shown by a report from the S. S. *West Ivan* (en route from the Orient to San Francisco) on the morning of the 26th, when in latitude 37° N., longitude 151° W. On the morning of the 27th, the *West Ivan* in latitude 37° N., longitude 148° W.; *Bearport* in latitude 39° N., longitude 154° W.; *Protesilaus* in latitude 52° N., 157° W., and the *Wairuna* in latitude 36° N., longitude 140° W., showed the cyclonic circulation around a large storm, but no high winds or low pressures were reported. On the morning of the 28th, the *West Ivan* reported a barometer of 29.44 inches, with fresh southeasterly winds and rain, and was nearing the center of the storm, while the *Bearport*, about 500 miles to the northwest, reported fresh northwesterly gales. Based upon these reports the following statement was made to the manager of the Associated Press: "A storm is central about 1300 miles off the California-Oregon coast moving eastward and will probably reach the coast about Friday evening (March 30) and extend later into California and break the drought." Advisory warnings were also sent to all ports from San Francisco north, advising shipping about to sail for the Orient of the location of the storm and the time it would reach the coast.

On the afternoon and evening of the 28th, the *West Ivan* sent the following reports:

> 1 p m, barometer 29.34, wind southwest, force 10; 3 p m, barometer 29.26, wind southwest, force 10; 9 p m, barometer 29.08, wind west, force 9, and at 11 p m, barometer 29.14, wind west, force 9—

Showing that she had passed through the center of the storm. At this time the weather was clear over the entire Pacific coast and a marked warm wave was in progress. Cloudiness began to increase along the coast Friday morning from San Luis Obispo northward; by Saturday morning rain had begun at all coast stations from San Francisco north, and by night the rain area had extended over western Washington, western Oregon, northern California, and the northern portion of southern California.

## SOME TEMPERATURE AND HUMIDITY RELATIONS OF THE AIR.

By W. J. HUMPHREYS.

[Weather Bureau, Washington, D. C., May 2, 1923.]

The following is only a condensed, and slightly modified, derivation of some of the more interesting portions of an important paper by Dr. C. W. B. Normand, published in 1921 as Part 1, Vol. 33, of the *Memoirs of the Indian Meteorological Department*.

Let an aspiration psychrometer meet the following conditions, as it may to any required approximation:

1. That there be no net radiation gain or loss by the thermometer element.
2. That there be no addition of heat to, or subtraction from, the system, air, water vapor, and water, within and passing through the psychrometer.
3. That the exit air be saturated. This assumption is not necessary, but convenient.
4. That the pressure be constant.

Let $T$ be the absolute temperature of perfectly dry intake air (if not fully dry, some of the following equations will need slight but obvious changes); $T'$ the absolute temperature of the wet bulb; $C_p$ and $C'_p$ the specific heats of dry air and of water vapor, respectively, at constant pressure; and $x$ the mass ratio of water vapor to dry air in saturated air at the temperature $T'$.

Then, counting from the freezing point, the heat in $1+x$ grams of saturated air at the temperature $T'$ is

$(C_p+C'_p x)(T'-273)$, which, since the process is adiabatic, is equal to the heat in the initial stage,

$$C_p(T-273)+x(T'-273).$$

That is:

1. The heat content of any air equals the heat content of the same air saturated at its wet-bulb temperature minus the heat content of the liquid water required so as saturate it.

2. The wet-bulb temperature of air adiabatically cooled, whether much or little, by evaporation into it from spray or other source, is constant.

3. If the wet-bulb temperatures of several portions of air are equal that of their mixture will be the same, however different their actual temperatures.

Furthermore, since the quantity of heat added to an object divided by the current absolute temperature of that object is the change in its entropy, the entropy per gram of dry air at the absolute temperature $T$, counting from 0° C. is

$$C_p\int_{273}^{T}\frac{dT}{T}=C_p\log\frac{T}{273}.$$

Similarly the entropy of $1+x$ grams of saturated air at the absolute temperature $T'$, also from 0° C. is, since the specific heat of water is one,

$$C_p\log\frac{T'}{273}+x\log\frac{T'}{273}+\frac{Lx}{T'},$$

in which $L$ is the heat of vaporization of a gram of water at the absolute temperature $T'$.

But

$$C_p\log\frac{T}{273}=C_p\log\frac{T'}{273}+\frac{Lx}{T'},\text{ nearly,}$$

since, on putting $Lx=C_p(T-T')$, the expression reduces to

$$\log\frac{T}{T'}=\frac{T}{T'}-1-\tfrac{1}{2}\left(\frac{T}{T'}-1\right)^2+\tfrac{1}{3}\left(\frac{T}{T'}-1\right)^3\ldots\ldots=\frac{T}{T'}-1,$$

nearly, which is true for all ordinary values of $T/T'$.

Hence, in Normand's words:

> The entropy of any air approximately equals the entropy of the same air saturated at its wet-bulb temperature *minus* the entropy of the liquid water required so to saturate it.

## ATMOSPHERIC TEMPERATURE AND THE CODLING MOTH.

By CHARLES C. GARRETT, Meteorologist.

[Weather Bureau, Walla Walla, Wash., Sept. 8, 1922.]

Among the numerous insect pests that infest the orchards of the United States and cause great losses to fruit growers, undoubtedly one of the most destructive of those that attack apples and pears is the codling moth. In a letter to the writer the District Horticulturist for the southeast Washington fruit district stated that in the season of 1918 the Yakima Valley apple growers suffered a loss of over \$2,000,000 due to the ravages of the codling moth alone. The Walla Walla district fared somewhat better, but the shipping data kept by the Horticultural Department showed that 28 per cent of all the apples were culls, and in accordance with the State horticultural laws were necessarily shipped to by-product plants, fed to hogs, or left to rot upon the ground. Conservatively speaking, at least 26 per cent of this total was accounted for by the codling moth.

The codling moth passes the winter in a cocoon, mostly under the loose bark of the trees. In early spring the larvae begin to transform into pupae, and soon after the apple blossoms have fallen the moths begin to emerge and continue to do so until the middle of summer. They lay their eggs chiefly on the leaves of the trees. On hatching, the young larvae seeks the easiest place to enter the apple, which is furnished by the calyx, or blossom end of the fruit, although a certain proportion enter through the stem end or through the skin. Between three and four weeks are spent by the larvae, or worms, in the fruit. Most of the wormy fruit falls before the larvae emerge.

In ordinary seasons, in northwestern apple districts, the codling moth has three generations and a partial fourth. Also, under ordinary weather conditions, the broods hatch at distinct periods. Dates of the main portion of each brood's hatching are determined, from which proper dates for spraying can be ascertained.

The means of control of the codling moth consist in covering the fruit and foliage with a poison mixture by spraying with a force pump. The first, or calyx spray, is begun when most of the petals have dropped, with calyx cups still open to receive the poison, and finished before the calyxes are closed. Succeeding sprays, known as cover sprays, are applied at varying intervals during the late spring and summer seasons for combating the later brood larvae.

As the cost of spraying adds materially to the expenses of an orchard, it is very essential that the work be done when it is most effective, and that, in order to avoid waste, no more be done than necessary to combat the pests. Most progressive fruit growers have come to depend upon the advice of the State horticulturists for proper dates for spraying.

Codling moth cages, in which dormant larvae are placed early in the season, are distributed throughout a district, care being taken to have each cage correspond in every way to natural conditions. The length of time from the appearance of the moth, or adult butterfly, to the appearance of its offspring, the young larvae, is a known quantity, provided the atmospheric temperature is observed and recorded. While it has long been recognized that climatic factors influence the severity of the ravages of the codling moth, it was not until recent years that the close relationship that exists between the temperature of the air and the development and activity of the moths has been studied and charted. Here is where the services of the meteorologist are needed in cooperation with those of the entomologist and horticulturist.

In a letter to the writer, dated August 21, 1922, Mr. E. J. Newcomer, entomologist, United States Bureau of Entomology, who has been engaged for several seasons in deciduous-fruit insect investigations in the Yakima Valley, Washington, stated: "Codling moths do not deposit eggs when the temperature is below 60° F. Three fourths of the eggs are laid between 3 p. m. and 9 p. m." Mr. Newcomer kindly furnished a diagram which is repro-

FIG. 2.—Moth cage.

FIG. 1.—Snowfall at La Crosse, Wis., March 4, 1923.

duced with this paper (fig. 1). This diagram shows graphically the relationship that exists between the late afternoon and evening temperature and the number of codling moth eggs laid daily. The average daily temperature for the 6-hour period, 3 p. m. to 9 p. m., is

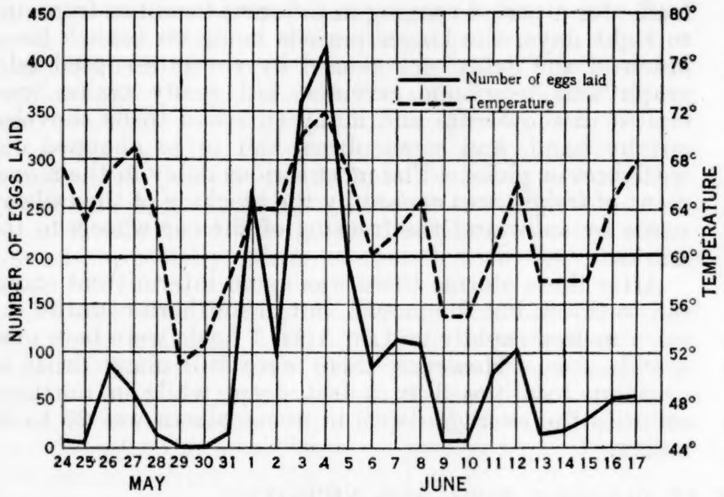


FIG. 1.—Relationship between late afternoon and evening temperature and the number of eggs laid daily by the codling moth.

shown on the chart by the broken line. The number of eggs laid is indicated by the solid line. Mr. Newcomer states that this is merely a sample taken from their records for four years. It will be seen that when the temperature drops below the 60° line, the number of eggs laid drops to zero or nearly to zero. According to Mr. Newcomer, a temperature of 60° or higher at 8 p. m. for two or three nights in succession will produce enough eggs to make a spray necessary, and that as these eggs will hatch in from one to three weeks, depending on the temperature, the spray must be applied accordingly. He further states that if the weather turns cold, that is, with maximum temperatures of 70° or lower, after these eggs are laid, the spray would not have to be on the trees for ten days or two weeks, while if it remains warm (maximum 75° or higher) the spray should be on in a week.

With the desire of cooperating as fully as practicable with the office of the district horticulturist in the work of determining the proper spraying dates for codling moth, the Walla Walla station of the Weather Bureau has installed thermometer shelters in three different parts of the Walla Walla fruit district. Each shelter is equipped with maximum and minimum thermometers and a short-range thermograph. As the temperature varies considerably in different parts of the district owing to differences in topography, more than one station is needed for best results. Two of the shelters are located in commercial apple orchards, and one in the yard of the writer's home in the city of Walla Walla. These special stations have been in operation for the last five seasons, and the records, in the words of one of the horticulturists, "have played a large part in codling-moth control in this district." Those that are located in the orchards are in close proximity to the codling-moth cages, and the records are kept by the orchardists who also keep the records of moth emergence. A view of one of the moth cages is shown in Figure 2. These are located in the Pomona orchard, northeast of Walla Walla.

## THREE WISCONSIN SNOWSTORMS.

By W. P. STEWART, Meteorologist.

[Weather Bureau, Milwaukee, Wis., April 21, 1923.]

The average snowfall in Wisconsin during March, 1923, was 19.8 inches. This is the greatest of record and is more than double the usual March snowfall. The greatest previous average for the State was 18.3 inches in 1891, and the least, 0.8 inch in 1910. Because of snowdrifts, highways throughout Wisconsin were impassable except for horse-drawn vehicles during the greater part of the month.

In most sections it was a month of frequent and heavy snows. Snow fell in some part of the State every day in the month but one. The first general and considerable snowfall occurred on March 4. This was heaviest in the vicinity of La Crosse where much damage was done to trees and overhead-wire systems. This was followed by intermittent snows from the 6th to the 9th. Then followed a series of 3 storms during which most of the month's snowfall occurred; crossing the State in rapid succession they made almost one continuous snowstorm throughout the second decade. These storms delayed rail traffic, damaged overhead-wire systems, blocked highways, and caused an economic and property loss in Wisconsin estimated at over $1,000,000.

The first of these three storms occurred on March 11, 12, and 13, in connection with the movement eastward across the State of a barometric depression of unusual intensity. During its passage the barometer at Milwaukee fell to 28.82 inches, sea-level reading. This is the lowest of record with one exception. The snow from this storm was unusually moist, so there was little drifting, notwithstanding a gale of 30 to 60 miles. The snowfall in southern and eastern Wisconsin ranged from 6 to 20 inches, the heaviest being in southern counties near Lake Michigan. The moist snow, at first mixed with some rain and sleet, stuck to wires, poles, and trees, and froze there. This made a coating of porous ice, or mixed ice and snow, which on wires and the small branches of trees and shrubbery was about 1½ inches in diameter. Over a wide area in southern and southeastern Wisconsin branches of trees, and in many cases whole trees, broke down. These in turn, aided by the gale, bore down thousands of telegraph and telephone poles and many miles of wire. One company alone estimated its loss from this cause at $250,000. Telegraph and telephone services were more or less seriously delayed for approximately 5 days.

The second of these snowstorms began during the night of March 14 in connection with another energetic disturbance which crossed the State from southwest to northeast on the 15th. This caused a snowfall which in central, eastern and southern counties averaged from 3 to 12 inches. In this storm the wind was not so high, but the snow was comparatively dry and drifted badly.

The third storm crossed Wisconsin on the 17–18th, causing snow which, in southern and eastern counties, ranged from 3 to 11 inches. In many localities this storm was described as the worst of the three. There was a fine, sleet-like snow, driven by a high wind, and accompanied by a rapid fall in temperature. At Milwaukee the temperature fell from 38° at 1 a. m. the 18th, to −3° at 6 a. m. the 19th. In this cold wave the temperature fell to −10° along the middle Illinois border, and to −20° to −30° or lower in the northern part of the State. At the end of this storm there were many snowdrifts in southeastern Wisconsin from 8 to 10 feet deep.

Prior to the second of these storms the snow had melted slightly and there was considerable soft snow, and in many places slush and water, on streets and highways and in railway cuts. On highways this had been cut into deep ruts wherever the roads were passable. With the advent of severe cold this mass was frozen into solid ice, much of which remained on the highways until the middle of the first decade in April.

On railway and interurban lines the combined effect of the three snowstorms and the cold wave was to tie up traffic for a period ranging in different localities from one to eight days, the longer periods being on branch lines. Much of the delay was caused by the interrupted telegraph and telephone services, but many trains were stalled in snowdrifts and many cuts had to be shoveled out by hand, and some places had to be chopped out with axes or picks. The most serious delay in the movement of freight was caused by the blocking of the railway yards by snow and the freezing of the car wheels to the tracks.

After these storms there was again intermittent snowfall to the end of the month, but in southern counties the snow melted rapidly and on April 1 fields were bare over a wide area. However, there were still many drifts in southern localities 3 to 6 feet deep, while in northern counties the average depth in many places was 20 to 30 inches.

## SNOWSTORMS OF MARCH 11-18, 1923, AT DUBUQUE, IOWA, AND VICINITY.

By H. MERRILL WILLS, Meteorologist.

[Weather Bureau, Dubuque, Iowa, March 26, 1923.]

Three rather remarkable snowstorms occurred in Dubuque and vicinity on March 11–12, 14–15, and 18.

*First storm.*—The snowstorm of the 11th–12th, in which 6 inches of snow fell within 24 hours, with 0.2 inch more added on the following night, was unusually heavy for the season and more than twice the greatest 24-hour fall of the present winter; but the outstanding feature of the storm was its peculiarly damaging effects. The storm attended the passage eastward near Dubuque of an area of unusually low barometric pressure, the lowest sea-level reading at Dubuque being 29.12 inches at 1:30 a. m. of the 12th. The storm began as rain on the evening of the 11th, gradually turning to wet snow. The temperature did not vary more than one or two degrees from freezing during the whole period of fall (8 p. m. of the 11th to 7 p. m. of the 12th), and the wet snow stuck to the trees, wires, poles, roofs, etc. The wind was only moderate, the maximum velocity being 23 miles from the north at 4:12 a. m., but the extreme weight of the clinging snow was sufficient to break down large branches of trees,—in some cases whole trees,—and telegraph and telephone wires and poles in all parts of Dubuque and vicinity; in many instances additional wires were broken down by the falling trees and branches. Practically every street was blocked in places by the debris. In some sections scores of broken branches could be seen from a given point and the appearance was such as to give the effect of a destructive windstorm.

Snowplows were used on the street railway lines all Sunday night, but the wet snow was difficult to remove, and all cars were off schedule Monday morning, some lines being blocked by snow and large branches or whole trees until about 9 a. m.

Electric light and power connections were destroyed in numerous sections of the city. Parts of the city were without electricity for hours. Telephone connection with the outside on Monday was entirely severed except for one toll line to McGregor. There were 43 poles down and 500 'phones out of commission in Dubuque County. All telegraph connection with the outside was cut off from 8 p. m. Sunday until 4:25 p. m. Monday when one wire to Minneapolis began to function. No weather reports were received by wire and consequently no map was published, but State forecasts were received by radiophone and published on cards. The damage to telephone and telegraph lines was apparently greatest in Dubuque County and those adjoining and thence eastward through Jo Daviess, Stephenson, and Winnebago Counties in Illinois. Doubtless the greatest havoc in any one county was in Jo Daviess County, Illinois. One telegraph company reported a loss of 600 poles between Dubuque and Chicago, and it is not known how many the other company lost.

Trains on all roads were greatly delayed, partially by the snow on tracks, but mainly on account of the demoralized wire service and consequent lack of dispatching facilities. Tracks were practically all cleared of snow by Monday night, but it required several days to restore dispatching services, and trains were generally off schedule during this period. The Chicago, Milwaukee and St. Paul reported all trains off schedule for two or three days, and that their wires were broken down almost entirely by falling trees and branches. The Illinois Central reported trains delayed for a like period, and that their worst trouble was east of Dubuque, where 210 poles went down within the first ten miles. The Chicago Great Western suffered to about the same extent in delay to trains, and reported a loss of 150 poles. The Chicago, Burlington and Quincy being double-tracked, was not so hampered by the lack of dispatching service, but lost 200 poles between Dubuque and Savanna, Illinois.

Summarizing the effects of the storm in Jo Daviess and Dubuque Counties and adjoining territory, the monetary losses in such properties as steam and electric railways, electric light and power lines, and telegraph and telephone lines, alone, aside from the inconvenience and innumerable losses to the public through delayed shipments, delayed passenger trains, inability to communicate with the outside, etc., are conservatively estimated at $120,000. Much of the repair work has been only temporary and it will be weeks before the work is completed. Not all estimates are yet available, and if the

losses in other counties of east-central Iowa and the northern tier of counties in Illinois were added, the total losses would doubtless reach several hundred thousand dollars.

*Second storm.*—By the evening of the 14th the snow of the 11th–12th had settled to a depth of 4.3 inches, when a second storm set in, amounting to 6.6 inches by 7 p. m. of the 15th, at which time the average depth of both old and new snow was 9.4 inches. This snowfall, while slightly larger than the first one, was not sufficiently wet to stick to surfaces and consequently had no such disastrous results. However, the snow on tracks caused considerable delay to trains and street cars, although the wind was light and there was but little drifting. The general effects of the storm could not be considered serious, especially when compared with the preceding one.

*Third storm.*—Before the damage from the storms of the 11th–12th and 14th–15th had been repaired, and with 4.5 inches of snow remaining on the ground from the two previous storms, the third heavy storm within a week occurred on the 18th. This fall averaged 6.7 inches and brought the total depth on ground to 11.0 inches—the greatest depth on the ground at one time during the present winter. The total fall from the three snows was 19.5 inches, as compared with the total previous fall for the entire winter of 13.9 inches, or about 40 per cent more. This phenomenal snowfall in so short a period is without precedent in this locality. Moreover, not since March, 1891, has there been so large a fall in any one month as that which fell from the 11th to the 18th, inclusive.

The fall occurred practically during the daylight hours of Sunday, and was of the type popularly regarded as a "blizzard." The snow was dry and was accompanied by moderately high wind and a cold wave which was severe for the season, the temperature falling from 39° at 9 p. m. of the 17th to 1° above zero at 3 p. m. of the 18th, and continuing to fall gradually thereafter to 7° below zero at 6 a. m. of the 19th. The heavy drifting snow, high wind, and severe cold wave obviously added new difficulties to the work of clearing away the effects of the previous storms, especially that of repairing the wire systems.

The most far-reaching consequences of this storm, however, were to be found in the constantly drifting snow on the electric and steam railway tracks. Trains were delayed for hours due to blocked tracks. One train from Chicago on the Illinois Central due Sunday night at 11 p. m. arrived on Monday 11 hours late, and an east-bound train was stalled in the drifts east of Freeport, Illinois practically all of Sunday night. All railway lines suffered alike from snow-blocked tracks, and some lines were bothered greatly by derailments due to the hard-packed snow.

Country roads were quite generally blocked by the deep drifts for more than a week, during which the snow settled slowly to a depth of 3 inches at this writing.

LATER NOTE (MARCH 29, 1923.)

A final estimate has just been received from Jo Daviess County, Illinois, giving the losses from the storms as follows:

| | |
|---|---|
| Number poles down (all wire services) | 677 |
| Time required to make repairs (weeks) | 8 |
| Money loss from above items | $9,000 |
| Damage to trees, money loss | $1,000 |
| Average delay to trains, for a period of 48 hours (hours) | 6 |

These losses are for the entire county but the figures in money losses are believed far too low, judging from estimates and advices received from representatives of the four railroads passing through Dubuque; that is, the loss of 677 poles would entail a much larger expense than $9,000. The number of poles is probably correct.

The wind was doubtless a large factor in breaking down the wires and poles but it is impossible to separate the contributing causes (wind and weight of snow on wires).—*H. M. W.*

## THE STORMS OF MARCH 11-12, 1923, IN ILLINOIS.

By CLARENCE J. ROOT, Meteorologist.

[Weather Bureau Office, Springfield, Ill., Apr. 12, 1923.]

A deep barometric disturbance crossed Illinois during the night of the 11th–12th. At 7 p. m. of the 11th its center was located in southern Missouri and by the following morning the center had advanced to Chicago. The sea-level barometer reading at Chicago (28.70 inches) and Peoria (28.89 inches) were the lowest of record, and at Springfield (28.82 inches) the lowest but one. Heavy precipitation and strong gales were general throughout Illinois. The maximum wind velocity at Springfield was from the southwest, but at Chicago, Peoria, and Davenport the maximum velocity came from the northeast. The strong, general winds caused damage to property in nearly all parts of the State. Poles and wires were blown down, buildings unroofed or otherwise injured, farm structures and outbuildings destroyed, trees torn or uprooted, windows broken, and fences demolished. In a few cases livestock were killed, but so far as is known no person was killed or even injured. The damage to property was not particularly severe in any one locality, but it was so widespread that in the aggregate the loss was considerable. One of the features of the storm was the interference with electric light, telephone, and interurban services.

In the extreme southeastern part of the State there seems to have been several local winds within the general storm. These winds occurred between 8:30 p. m. and 9 p. m. of the 11th. The storm in Gallatin County was probably a tornado. It entered at the southwest corner and crossed the county diagonally. The path of principal destruction was 300 yards in width, and the money loss in the direct path of the tornado about $10,000. In Hamilton and Johnson counties there is not enough evidence to classify the winds as tornadoes. In the latter county hundreds of fruit trees were destroyed. There are important commercial apple orchards in Johnson County.

In the northern part of the State rain and wet snow fell throughout the night. The rain froze as it fell and the snow adhered to all objects with which it came in contact. Trees, wires, and poles were covered with ice and snow. At Oregon the ice coating was 3 to 4 inches thick on the wires. Mr. N. V. Woleben, cooperative observer at Marengo, weighed the incrustation of snow and ice and found it to be twelve ounces to the foot of wire. This condition was general throughout that portion of Illinois lying within 50 or 60 miles of the Wisconsin border. With this accumulation of ice on the wires, the destructive

effect of the wind was much greater than in the parts of the State farther south. The snowfall ranged from 2 to 11 inches in this area. The combination of pole and wire destruction and heavy snow greatly disturbed transportation of all kinds. The snow drifted in places. Electric lines had the snow and broken poles and wires to contend with, and steam lines also impeded by the snow, were unable to dispatch trains on account of lack of communication facilities. Trains, in some cases, were dispatched by radio. Passengers were marooned over night in interurban cars, and in the cities street car service was suspended. Some trains on the steam roads were canceled, and at Marengo the interurban line did not resume operations until the 28th. In Chicago street-car and steam transportation were considerably hampered by the snow. In the western part of Carroll County telegraph poles were torn out and the tops stuck in the ground with the butts up.

The Chicago, Burlington and Quincy Railroad sent out about 150 miles of wire to repair damage. A good idea of the effect and extent of the storm is given in the following report furnished by the Illinois Bell Telephone Co., the leading telephone company in the State:

> We had around 6,000 poles down and we expect the total cost of restoration will be something in the neibgorhood of $350,000. In addition to the pole damage there was, of course, much damage to wires due to their breaking on account of accumulated snow, and wind, and also on account of tree limbs falling on them. The principal damage occurred from the west limits of Chicago to the general neighborhood of Rockford and extended, with less severity, from there to Rock Island and Galena. In this area there was a great deal of wet snow which froze on the wires, and very heavy wind. We also had considerable trouble due, however, entirely to the wind pressure in the area around Decatur and extending as far south as Nashville, but the damage was in no way as serious as that in the northern part of the State. We have no definite data as to the extent of the damage suffered by other wire using companies, but we know, in general, that the rural telephone lines of the companies connecting with us in the north end of the State suffered severely.

The storm was so widespread that it is next to impossible to secure an accurate estimate of the money loss, but considering the information at hand it is probable that the loss for the entire State was in the neighborhood of $800,000.

With the greater part of the snow still present to hamper the work of restoration, an additional fall of 3 to 11 inches occurred from the 14th to 16th. There was little drifting, but the street cars at Rockford were again put out as the tracks were frozen solid with ice. With most of the accumulated depth of the 16th still on the ground, a third storm within a period of eight days occurred on the 18th. This storm produced an additional amount of 2 to 8 inches, the total depth on ground at Freeport being 25 inches. The storm of the 18th was of the blizzard type, with strong winds, much drifting, and rapidly falling temperature. By the following morning the temperature in northern Illinois was well below zero. Passenger trains were many hours late. Some freight trains were stalled and others were annulled. Highways were badly blocked for several days. The week of March 11 to 18, 1923, will remain fresh in the memories of the people of northern Illinois for a long time.

## TORNADO IN TENNESSEE ON MARCH 11, 1923.

By R. M. WILLIAMSON, Meteorologist.

[Weather Bureau, Nashville, Tenn., Apr. 25, 1923.]

Destructive winds occurred over most of the State during the night of March 11–12, in connection with a storm of unusual intensity centered over Missouri at 7 p. m. of the 11th. The severest part of the storm in this State was felt in the western counties about 8 p. m., in the central portion about 10 p. m., and in the eastern portion after midnight. At Nashville, and probably at most other points also, most of the damage was done within a period of ten minutes, or less, when the wind attained its highest velocity. During this period there was heavy rainfall and a vivid lightning display. Instead of the usual series of local thunderstorms, or tornadoes, that strike here and there within the most active portion of a barometric depression, there was in this case what appeared to be a wave or crest of wind of almost hurricane force that advanced eastward across the State, including all portions in its sweep but wreaking its fury mostly in the western and central portions. At the time of this crest the wind shifted from southeast and south to southwest and continued from that direction during the following twelve hours or more.

In two of the western counties the wind assumed the form of a real tornado of serious character. Its path was rather more limited than usual, being from 200 to 400 yards wide and not over 15 miles long. The destruction of human life was unusually heavy, considering the small extent of the storm. This was due to the fact that two villages lay in its path, namely, Deanburg, Chester County, and Pinson, Madison County, about 10 miles apart. The latter, a village of about 500 inhabitants, was almost a total wreck. At Deanburg 2 persons were killed and about 20 injured; at Pinson 17 or 18 persons were killed and some 40 or 50 injured. The property loss included the school building, two churches, 60 or more dwellings, many barns, outhouses, fences, etc., and about 60 head of stock, a total damage of approximately $100,000. The tornado originated at or near Deanburg, extreme western Chester County, at 8 p. m. and traveled rapidly northeastward to Pinson, in the adjoining county, passing there about 8:10 to 8:15 p. m. It was lost sight of three miles northeast of Pinson, having traveled a distance probably not exceeding 10 miles. Since it occurred at night and in the midst of a general windstorm of unusual severity, there was probably very little observation of the appearance of the storm clouds, and hence no accurate description of the approach of the storm is available.

# CLIMATOLOGICAL DATA FOR CENTRAL AMERICA.

By W. W. REED, Meteorologist.

[Prepared under the direction of the Chief of Climatological Division, Weather Bureau, Washington, D. C., April 28, 1923.]

The purpose of this paper is to combine in convenient form the widely scattered weather data for the several divisions of Central America found in the works mentioned under "Bibliography."

It is to be regretted that some regions will be represented by very meager data, that many of the series of observations are broken or even fragmentary, and that the periods of time to which the tables relate are synchronous for but few of the stations.

Before presenting the tabulated data it will be well to make a general survey of the physical influences that give to this region its rather diversified climate.

With respect to temperature conditions, three zones may be distinguished: The hot zone, *tierra caliente*, extending from the coast to an elevation of about 400 feet; the temperate zone, *tierra templada*, subdivided into two levels, the lower lying between the hot zone and an elevation of about 3,500 feet, the upper between this elevation and that of 7,500 feet; and the cold zone, *tierra fria*, including all regions with greater elevations.

The principal vegetable product of the different levels will indicate the effect of change of climate with ascent from the sea. The typical product of the hot zone is the banana, those of the lower and upper subdivisions of the temperate zone are coffee and cereals; the cold zone is not well adapted to agriculture, temperature below 40° occurring in all months of the year.

The precipitation received over this region shows wide variations both as to amount and distribution through the year and marked contrasts are to be found within short distances. This may be explained by refering to the rain-producing causes and to the interposed mountain barriers which set well-defined limits to which these causes are effective.

In his paper "Central American Rainfall" Harrington classifies the rains of this region under the following types: *Invierno*, trade wind, norther, and cyclonic. The *invierno* type is that due to the migratory movement of the equatorial rain belt following the course of the sun; its duration is from May to November, being somewhat shorter in the northern than in the southern regions. In the northern regions rains of this type have a single maximum about the time of the summer solstice, while in the southern regions there occur two maxima of precipitation corresponding roughly to the two zenith positions of the sun. In the interval, with diminished precipitation, there occurs about August the *veranillo*, or short dry season, which for reasons given later appears well defined only on the Pacific slope. With the passage of the sun to the south of the Equator and the consequent withdrawal of the rain belt there is marked diminution in this type of rainfall in November, and by December the *verano*, or long dry season, holds full sway, continuing until the coming of the rain belt about one month after the vernal equinox. The precipitation due to condensation of moisture carried by the trade winds is limited almost entirely to the Atlantic coasts and slopes, reaching its maximum from June to August. The rains accompanying "northers" generally extend no farther south than the crests of the mountains of Guatemala and to the northern coast of Honduras with maximum from December to February; those of rarer occurrence in connection with cyclonic disturbances in the Caribbean Sea reach, as a rule, to no great distance inland and appear only in the hurricane season. It is seen that nearly all of the Pacific coast receives rain from only the first of the sources mentioned, thus presenting the typical *invierno*, while the remaining regions have in addition to this other sources of moisture supply with rainfall throughout the year, the maximum amounts being received in some one of the months from June to November.

*Temperature.*—In this tropical region there is very little difference in temperature for stations at or near sea-level, but since the interior rises to considerable elevations there is found for the entire region a range in mean annual temperature of more than 20°. From an annual mean temperature of 80° at the coast stations there is decrease to a mean of 58° for an elevation of about 7,500 feet. For all levels temperatures are rather uniform throughout the year. Even at Quezaltenango (7,710 feet) the difference in the temperature means of the coldest and the warmest months is only 10°. The means at this station for January and June are 52° and 62° respectively, and by referring to similar values for the United States it is found that they are very near those for Washington for the months of April and May and for New Orleans for the months of January and March. Near the coasts the highest temperatures range about 95°; for moderate elevations they range about 90°, except where a valley exposure such as that of San Salvador may give extremes of 100° or slightly above; while for the most elevated station reporting (Quezaltenango) the highest temperature is 83°. Extreme minimum temperatures range from about 60° near the coast to 26° at the elevation of 7,700 feet.

Temperature means based on the formula max. + min. ÷ 2 are available for all stations with temperature records. These are given first, followed by tables giving mean maximum and mean minimum temperatures. Geographic coordinates and elevations are found in Table 7 under precipitation.

TABLE 1.—*Mean temperatures from daily extremes (° F.).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BRITISH HONDURAS. | | | | | | | | | | | | | | |
| Belize | 5 | 76.1 | 77.1 | 79.4 | 80.8 | 82.6 | 82.6 | 82.4 | 83.0 | 82.8 | 80.4 | 76.9 | 76.4 | 79.9 |
| GUATEMALA. | | | | | | | | | | | | | | |
| Chimax | 9 | 62.7 | 63.7 | 65.3 | 67.1 | 69.0 | 69.0 | 68.0 | 68.4 | 68.8 | 67.1 | 64.4 | 63.2 | 66.4 |
| Guatemala | 6 | 63.0 | 65.8 | 69.0 | 70.0 | 72.1 | 71.0 | 69.2 | 69.4 | 69.4 | 67.8 | 65.8 | 63.4 | 68.0 |
| Quezaltenango | 5 | 51.8 | 53.4 | 57.8 | 60.1 | 62.3 | 61.9 | 60.4 | 60.0 | 60.2 | 59.4 | 56.9 | 52.7 | 58.1 |
| SALVADOR. | | | | | | | | | | | | | | |
| San Salvador | 14 | 72.5 | 74.5 | 75.7 | 77.1 | 75.8 | 75.2 | 75.4 | 75.5 | 74.8 | 74.8 | 73.2 | 72.0 | 74.7 |
| NICARAGUA. | | | | | | | | | | | | | | |
| Bluefields | 3 | 78.3 | 77.7 | 80.8 | 82.4 | 80.8 | 79.2 | 79.3 | 79.3 | 79.2 | 79.5 | 79.2 | 78.4 | 79.5 |
| Greytown | 3 | 77.5 | 77.7 | 78.8 | 80.8 | 80.8 | 80.1 | 79.2 | 79.3 | 80.4 | 80.2 | 78.4 | 77.5 | 79.2 |
| COSTA RICA. | | | | | | | | | | | | | | |
| Ochoa | 3 | 74.8 | 75.0 | 75.9 | 77.4 | 78.8 | 78.3 | 77.4 | 77.5 | 78.6 | 78.6 | 76.8 | 75.6 | 77.1 |
| San Jose [1] | 5 | 67.3 | 68.7 | 70.2 | 70.5 | 70.7 | 69.2 | 69.1 | 68.8 | 68.6 | 68.4 | 68.3 | 66.9 | 68.9 |
| CANAL ZONE. | | | | | | | | | | | | | | |
| Ancon | 8 | 80.3 | 80.4 | 81.5 | 81.7 | 80.5 | 79.9 | 80.2 | 80.0 | 79.8 | 79.2 | 79.0 | 79.9 | 80.2 |
| Culebra | 7 | 77.6 | 77.5 | 78.5 | 79.7 | 79.4 | 79.1 | 79.0 | 79.0 | 78.8 | 78.3 | 77.8 | 78.0 | 78.6 |
| PANAMA. | | | | | | | | | | | | | | |
| Colon | 6 | 79.3 | 79.2 | 79.8 | 80.5 | 79.8 | 79.4 | 79.4 | 79.3 | 79.5 | 79.0 | 78.1 | 79.0 | 79.3 |

[1] Mean of readings at 6 a. m. and 1 p. m.

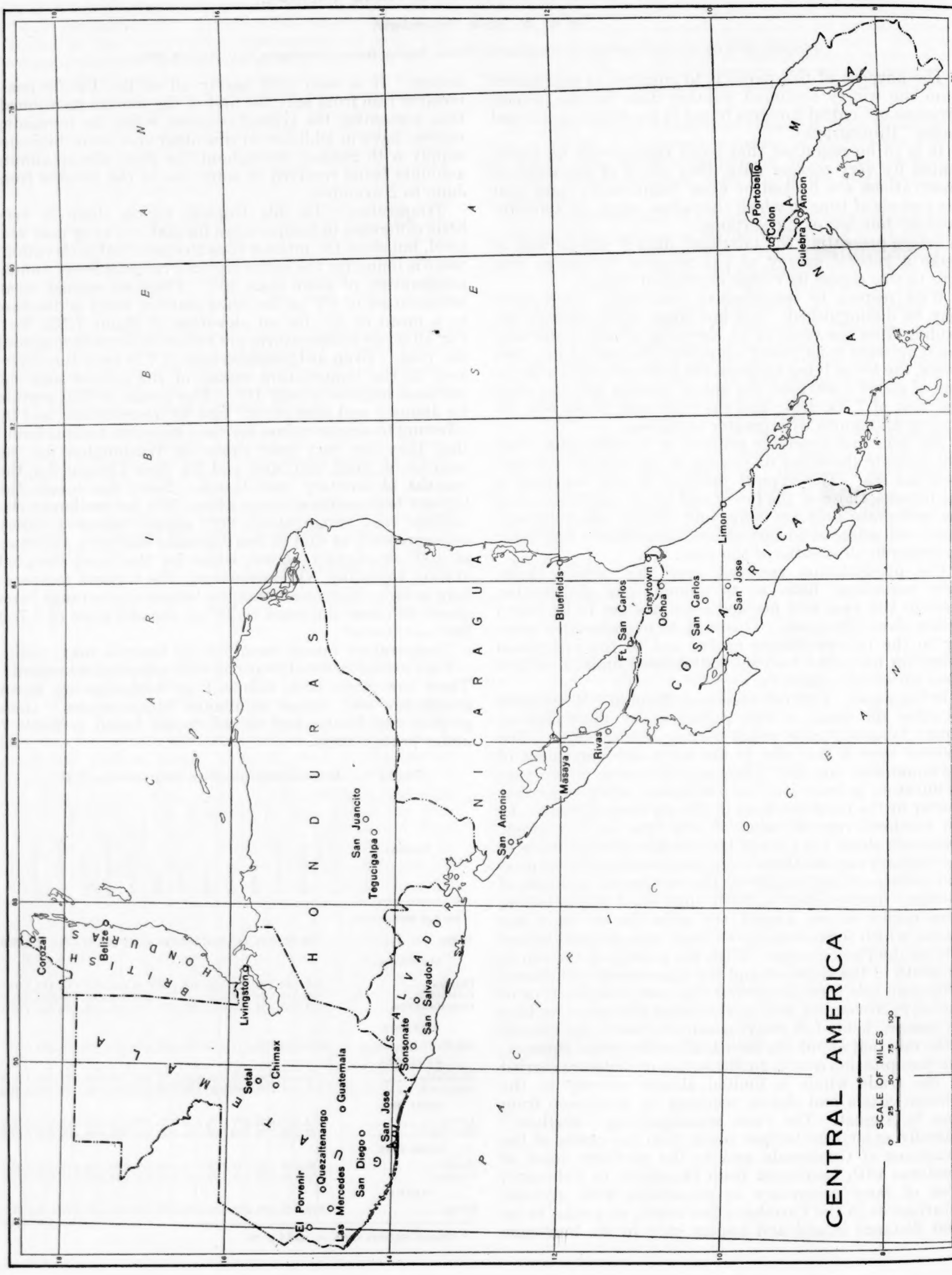
CENTRAL AMERICA
SCALE OF MILES
0 25 50 75 100
BRITISH HONDURAS
HONDURAS
NICARAGUA
COSTA RICA
Corozal
Belize
Livingston
o Chimax
Setal
o Guatemala
o Quezaltenango
El Porvenir
Las Mercedes
San Diego
San Jose
Sonsonate
San Salvador
Tegucigalpa
San Juancito
San Antonio
Masaya
Rivas
Ft. San Carlos
Bluefields
Greytown
Ochoa
San Carlos
San Jose
Limon
Colon
Portobello
Culebra
Ancon

TABLE 2.—*Mean maximum temperatures (° F.).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BRITISH HONDURAS. | | | | | | | | | | | | | | |
| Belize | 5 | 79.0 | 79.9 | 81.7 | 82.9 | 84.9 | 84.7 | 84.4 | 85.3 | 85.5 | 83.5 | 80.8 | 79.5 | 82.7 |
| GUATEMALA. | | | | | | | | | | | | | | |
| Chimax | 9 | 73.2 | 75.2 | 77.2 | 78.6 | 79.3 | 77.5 | 76.5 | 77.5 | 77.4 | 75.2 | 72.3 | 73.0 | 76.1 |
| Guatemala | 6 | 72.7 | 77.4 | 81.3 | 82.4 | 83.8 | 81.3 | 78.4 | 79.0 | 78.6 | 76.1 | 74.1 | 72.3 | 78.1 |
| Quezaltenango | 5 | 65.7 | 67.6 | 71.6 | 72.9 | 73.0 | 70.9 | 70.3 | 70.2 | 69.8 | 68.4 | 66.9 | 65.1 | 69.4 |
| SALVADOR. | | | | | | | | | | | | | | |
| San Salvador | 14 | 86.2 | 88.7 | 90.1 | 90.3 | 86.9 | 85.6 | 86.2 | 86.4 | 84.9 | 85.5 | 84.4 | 84.6 | 86.6 |
| COSTA RICA. | | | | | | | | | | | | | | |
| San Jose [2] | 5 | 75.2 | 77.5 | 79.5 | 78.4 | 78.3 | 75.9 | 75.4 | 75.4 | 75.4 | 74.8 | 75.4 | 73.2 | 76.2 |
| CANAL ZONE. | | | | | | | | | | | | | | |
| Ancon | 8 | 89.6 | 90.2 | 91.7 | 90.6 | 87.7 | 86.8 | 87.6 | 87.4 | 86.9 | 86.2 | 85.9 | 88.2 | 88.2 |
| Culebra | 7 | 85.7 | 86.3 | 87.6 | 88.6 | 86.6 | 85.9 | 85.9 | 86.0 | 85.9 | 85.2 | 84.0 | 85.3 | 86.1 |
| PANAMA. | | | | | | | | | | | | | | |
| Colon | 6 | 82.7 | 82.5 | 83.2 | 84.0 | 84.3 | 84.2 | 83.5 | 83.6 | 84.4 | 84.1 | 82.3 | 82.8 | 83.5 |

[2] Mean for 1 p. m.

TABLE 3.—*Mean minimum temperatures (° F.).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BRITISH HONDURAS. | | | | | | | | | | | | | | |
| Belize | 5 | 73.2 | 74.3 | 77.2 | 78.6 | 80.2 | 80.6 | 80.4 | 80.8 | 80.2 | 77.2 | 73.0 | 73.2 | 77.4 |
| | | 23 | 23.5 | 25 | 26 | 26.5 | 27 | 27 | 27+ | 27- | 25 | 23- | 23 | |
| GUATEMALA. | | | | | | | | | | | | | | |
| Chimax | 9 | 52.2 | 52.2 | 53.4 | 55.6 | 58.8 | 60.6 | 59.5 | 59.4 | 60.1 | 59.0 | 56.5 | 53.4 | 56.7 |
| Guatemala | 6 | 53.2 | 54.3 | 56.7 | 57.7 | 60.4 | 60.8 | 59.9 | 59.9 | 60.3 | 59.5 | 57.2 | 54.5 | 57.9 |
| Quezaltenango | 5 | 37.9 | 39.2 | 43.9 | 47.3 | 51.6 | 52.9 | 50.4 | 49.8 | 50.7 | 50.5 | 46.9 | 40.3 | 46.8 |
| SALVADOR. | | | | | | | | | | | | | | |
| San Salvador | 14 | 58.8 | 60.3 | 61.3 | 63.9 | 64.8 | 64.9 | 64.6 | 64.6 | 64.6 | 64.2 | 62.1 | 59.5 | 62.8 |
| COSTA RICA. | | | | | | | | | | | | | | |
| San Jose [3] | 5 | 59.4 | 59.9 | 61.0 | 62.6 | 63.1 | 62.6 | 62.8 | 62.2 | 61.7 | 61.9 | 61.2 | 60.6 | 61.6 |
| CANAL ZONE. | | | | | | | | | | | | | | |
| Ancon | 8 | 71.0 | 70.6 | 71.3 | 72.7 | 73.4 | 73.0 | 72.9 | 72.7 | 72.8 | 72.2 | 72.0 | 71.6 | 72.2 |
| Culebra | 7 | 69.7 | 69.0 | 69.7 | 71.0 | 72.2 | 72.2 | 72.1 | 72.0 | 71.8 | 71.4 | 71.6 | 70.7 | 71.1 |
| PANAMA. | | | | | | | | | | | | | | |
| Colon | 6 | 75.9 | 75.9 | 76.4 | 76.9 | 75.1 | 74.8 | 75.3 | 75.0 | 74.6 | 73.9 | 74.0 | 75.2 | 75.2 |

[3] Mean for 6 a. m.

Means for temperature obtained by use of the formula employed in Table 1 are probably slightly higher than the true values, hence the following table with probably more accurate values for a few stations is added.

TABLE 4.—*Mean temperatures by other formulae (°F.).*

(Compare with Table 1.)

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belize [1] | 8 | 74.8 | 76.6 | 79.2 | 79.9 | 81.9 | 82.4 | 82.6 | 82.6 | 82.0 | 79.3 | 76.1 | 73.6 | 79.3 |
| Chimax [1] | 14 | 59.7 | 61.3 | 63.5 | 66.0 | 67.5 | 67.3 | 66.2 | 66.6 | 66.7 | 64.8 | 62.8 | 59.9 | 64.4 |
| Guatemala [2] | 21 | 61.3 | 62.8 | 65.7 | 67.6 | 68.0 | 66.2 | 65.8 | 66.0 | 65.7 | 64.8 | 62.8 | 61.3 | 64.8 |
| Tegucigalpa [1] | 2 | 66.0 | 68.4 | 70.5 | 73.4 | 76.1 | 75.4 | 74.3 | 73,2 | 72.5 | 71.2 | 70.5 | 66.9 | 71.5 |
| San Salvador [3] | 23 | 71.9 | 72.8 | 74.7 | 76.1 | 75.9 | 74.4 | 74.5 | 74.2 | 73.4 | 73.1 | 72.4 | 71.8 | 73.8 |
| San José [4] | 12 | 66.0 | 66.7 | 67.8 | 68.7 | 68.9 | 68.2 | 67.6 | 67.5 | 67.6 | 67.3 | 66.9 | 65.8 | 67.4 |

[1] Reduction to true mean by Hann.
[2] Formula, 7a+2p+9p÷3.
[3] Formula, 7a+2p+9p+9p÷4.
[4] Hourly readings from thermograph.

TABLE 5.—*Temperature extremes—Maximum (°F.).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belize | 10 | 87 | 89 | 92 | 95 | 91 | 93 | 92 | 92 | 92 | 92 | 89 | 88 | 95 |
| Chimax | 11 | 83 | 88 | 91 | 90 | 88 | 86 | 82 | 82 | 84 | 84 | 84 | 84 | 91 |
| Guatemala | 13 | 86 | 85 | 86 | 90 | 89 | 86 | 84 | 83 | 82 | 82 | 83 | 83 | 90 |
| Quezaltenango | 6 | 78 | 73 | 79 | 80 | 83 | 77 | 77 | 75 | 75 | 75 | 72 | 69 | 83 |
| San Salvador | 5 | 101 | 103 | 103 | 103 | 103 | 97 | 96 | 98 | 100 | 101 | 102 | 102 | 103 |
| San José | 12 | 86 | 90 | 91 | 94 | 90 | 85 | 85 | 85 | 86 | 85 | 84 | 85 | 94 |
| Ancon | 8 | 93 | 95 | 96 | 97 | 96 | 95 | 95 | 94 | 93 | 95 | 94 | 94 | 97 |
| Culebra | 7 | 90 | 91 | 93 | 96 | 96 | 92 | 92 | 92 | 91 | 92 | 90 | 92 | 96 |
| Colon | 6 | 88 | 88 | 88 | 90 | 91 | 92 | 89 | 89 | 90 | 90 | 89 | 89 | 92 |

TABLE 6.—*Temperature extremes—Minimum (°F.).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belize | 10 | 59 | 58 | 61 | 60 | 69 | 72 | 72 | 70 | 72 | 67 | 61 | 56 | 56 |
| Chimax | 11 | 36 | 38 | 38 | 43 | 46 | 51 | 52 | 51 | 50 | 45 | 44 | 37 | 36 |
| Guatemala | 13 | 41 | 43 | 41 | 47 | 52 | 52 | 51 | 52 | 54 | 50 | 44 | 41 | 41 |
| Quezaltenango | 6 | 26 | 27 | 28 | 36 | 35 | 39 | 38 | 38 | 38 | 38 | 31 | 28 | 26 |
| San Salvador | 5 | 45 | 51 | 54 | 54 | 58 | 61 | 61 | 60 | 60 | 58 | 52 | 50 | 45 |
| San José | 12 | 50 | 47 | 48 | 51 | 53 | 56 | 56 | 56 | 56 | 56 | 52 | 49 | 47 |
| Ancon | 8 | 63 | 66 | 65 | 64 | 69 | 70 | 67 | 69 | 68 | 68 | 67 | 66 | 63 |
| Culebra | 7 | 60 | 59 | 61 | 62 | 68 | 67 | 67 | 68 | 67 | 66 | 67 | 64 | 59 |
| Colon | 6 | 70 | 71 | 67 | 72 | 71 | 70 | 70 | 71 | 71 | 70 | 69 | 66 | 66 |

*Precipitation.*—Relative to precipitation received, the region may be divided into two parts: The Pacific slope with moderately heavy rainfall of the *invierno* type, following the course of the sun from May to October, and with very light to scant amount during the *verano;* and the mountainous region, eastern slope, and eastern coast with rainfall throughout the year and with highly excessive amounts at many stations during the period of maximum fall. In the latter regions, where there is more than one source of moisture supply, there arise great

differences in the amounts of precipitation received annually, with considerable difference in the time of maximum, which occurs within the period from June to December. For the several political divisions the ranges in amounts are as follows: British Honduras, 50 to 80 inches; Salvador, 60 to 90 inches; Canal Zone-Panama, 70 to 160 inches; Guatemala, 30 to 200 inches; Nicaragua, 55 to 255 inches. The greatest annual average is 255 inches at Greytown, Nicaragua, and the least is 28 inches at the high station in Guatemala, Quezaltenango. Numerous stations in Guatemala have several successive months with average precipitation above 20 inches; this is found at Greytown also, the averages for July and December being the unusual amounts of 34 and 36 inches, respectively. The following are low averages at stations with long records for the period December–April: Rivas, Nicaragua, 2.34 inches; Guatemala, Guatemala, 3.06 inches; San Salvador, Salvador, 3.43 inches; San José, Costa Rica, 4.90 inches. Table 7 sets forth other interesting contrasts in precipitation.

TABLE 7.—*Monthly and annual average precipitation (inches).*

| Stations. | North latitude. | West longitude (Greenwich). | Elevation, feet. | Length of record, years. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BRITISH HONDURAS. | ° ′ | ° ′ | | | | | | | | | | | | | | | |
| Belize | 17 29 | 88 14 | ........ | 24 | 7.44 | 3.22 | 2.47 | 2.23 | 4.91 | 7.86 | 8.23 | 8.27 | 9.38 | 10.58 | 13.29 | 6.65 | 84.53 |
| Corozal [1] | 18 22 | 88 26 | ........ | 16 | 2.57 | 1.47 | 1.24 | 1.36 | 3.99 | 8.74 | 6.95 | 5.80 | 6.41 | 6.70 | 5.19 | 2.05 | 52.47 |
| GUATEMALA. | | | | | | | | | | | | | | | | | |
| Chimax | 15 40 | 90 10 | 4,260 | 20 | 6.00 | 4.22 | 4.54 | 4.28 | 8.28 | 11.85 | 10.11 | 7.96 | 9.88 | 13.54 | 8.63 | 6.68 | 95.97 |
| El Porvenir | 14 59 | 91 57 | 3,000 | 14 | 2.54 | 2.85 | 5.13 | 10.46 | 21.70 | 27.87 | 18.98 | 20.28 | 23.29 | 21.88 | 8.40 | 2.74 | 166.12 |
| Guatemala | 14 37 | 90 31 | 4,855 | 29 | .30 | .13 | .47 | 1.22 | 6.00 | 10.84 | 7.98 | 7.77 | 9.11 | 6.76 | .94 | .32 | 51.84 |
| Las Mercedes | 14 42 | 91 46 | 3,280 | 20 | 1.42 | 2.05 | 3.70 | 8.27 | 20.24 | 24.65 | 18.98 | 20.63 | 23.46 | 21.93 | 6.54 | 2.28 | 154.15 |
| Livingston | 15 49 | 88 47 | 65 | 3 | 25.62 | 7.50 | 8.53 | 5.80 | 18.85 | 17.80 | 23.34 | 26.11 | 24.16 | 13.14 | 13.09 | 14.98 | 198.92 |
| Magdalena | 15 24 | 91 7 | 7,220 | 11 | .26 | .12 | 1.22 | 1.34 | 3.18 | 6.72 | 5.49 | 5.42 | 7.14 | 4.32 | 1.15 | .23 | 36.59 |
| Panzos | 15 25 | 89 40 | 118 | 7 | 3.34 | 1.49 | 2.93 | 3.22 | 10.54 | 23.17 | 23.82 | 17.39 | 18.60 | 10.39 | 5.07 | 2.94 | 122.90 |
| Patulul | 14 25 | 91 10 | 666 | 3 | .66 | .11 | 1.59 | 3.25 | 16.97 | 19.47 | 11.77 | 21.26 | 19.06 | 16.86 | 5.16 | .20 | 116.3 |
| Quezaltenango | 14 57 | 91 30 | 7,710 | 4 | .04 | .14 | .02 | .59 | 5.13 | 6.18 | 3.26 | 3.86 | 4.75 | 3.54 | .47 | .21 | 28.19 |
| Samac | 15 40 | 90 20 | 4,260 | 17 | 12.16 | 8.46 | 8.50 | 9.09 | 12.76 | 17.80 | 12.95 | 10.39 | 14.65 | 22.60 | 15.87 | 13.82 | 159.05 |
| Salama | 15 6 | 90 17 | 3,050 | 4 | .00 | .00 | .47 | 1.89 | 3.15 | 9.17 | 4.02 | 3.19 | 3.11 | 3.62 | 1.34 | .12 | 30.08 |
| San Diego | 14 22 | 90 49 | 1,800 | 6 | 1.14 | 1.46 | 5.39 | 6.50 | 19.65 | 27.48 | 12.36 | 14.49 | 20.08 | 19.06 | 6.42 | 1.02 | 135.05 |
| San Francisco Miramar | 14 40 | 91 48 | 2,430 | 25 | 1.50 | 1.56 | 3.54 | 9.20 | 19.80 | 27.04 | 19.52 | 22.35 | 28.18 | 25.64 | 7.50 | 2.99 | 168.82 |
| San Jose | 13 55 | 90 50 | 10 | 3 | .00 | .44 | .00 | .32 | 4.77 | 11.58 | 8.38 | 10.02 | 11.58 | 7.20 | 1.26 | .25 | 55.80 |
| San Luis | 14 53 | 92 0 | 2,300 | 11 | 1.96 | 3.65 | 4.87 | 12.26 | 23.97 | 28.04 | 21.25 | 25.90 | 31.18 | 27.46 | 9.86 | 2.31 | 192.71 |
| Setal | 15 47 | 90 10 | 2,450 | 17 | 15.24 | 11.30 | 9.96 | 8.54 | 11.46 | 20.98 | 18.11 | 15.43 | 19.84 | 28.46 | 18.54 | 15.28 | 193.14 |
| HONDURAS. | | | | | | | | | | | | | | | | | |
| San Juancito | 14 17 | 86 40 | ........ | 4 | 1.94 | .91 | 2.50 | 3.14 | 6.72 | 11.22 | 8.36 | 7.21 | 8.00 | 7.81 | 5.64 | 2.24 | 65.69 |
| SALVADOR. | | | | | | | | | | | | | | | | | |
| La Laguna | 13 39 | 89 15 | 2,490 | 5 | .08 | .04 | 1.57 | 1.81 | 8.23 | 9.92 | 15.47 | 11.46 | 11.22 | 14.53 | 1.34 | .08 | 75.75 |
| Mirasol | 13 47 | 89 15 | 2,300 | 5 | .00 | .12 | 2.80 | 3.94 | 8.90 | 10.94 | 14.13 | 13.62 | 11.42 | 10.35 | 2.13 | .00 | 78.35 |
| San Salvador | 13 42 | 89 12 | 2,155 | 23 | .17 | .21 | .50 | 1.96 | 6.69 | 11.13 | 12.11 | 11.72 | 11.03 | 10.37 | 1.79 | .59 | 68.27 |
| Santa Lucia | 13 45 | 89 16 | 4,500 | 5 | .12 | .04 | 2.48 | 4.33 | 8.07 | 12.09 | 18.07 | 15.16 | 14.25 | 12.32 | 2.60 | .16 | 89.69 |
| Santa Tecla | 13 39 | 89 18 | 3,000 | 8 | .00 | .08 | .32 | 1.26 | 8.50 | 10.04 | 13.35 | 12.68 | 12.16 | 7.56 | 2.87 | .47 | 69.29 |
| Sonsonate | 13 43 | 89 44 | 745 | 10 | .00 | .08 | 1.18 | 1.57 | 7.23 | 9.55 | 9.79 | 9.99 | 9.68 | 11.22 | 2.08 | .23 | 62.60 |
| NICARAGUA. | | | | | | | | | | | | | | | | | |
| Bluefields | 12 0 | 83 45 | ........ | 5 | 9.86 | 6.93 | 3.61 | 3.12 | 8.08 | 17.00 | 28.58 | 16.07 | 8.74 | 11.22 | 11.40 | 14.28 | 138.89 |
| Fort San Carlos | 11 8 | 84 48 | 108 | 3 | 4.45 | 2.99 | 1.02 | 1.65 | 8.54 | 10.94 | 12.68 | 10.83 | 12.09 | 11.06 | 8.23 | 5.08 | 89.56 |
| Granada | 11 56 | 85 58 | 197 | 10 | .22 | .04 | .10 | .87 | 7.89 | 12.87 | 11.34 | 8.66 | 10.38 | 12.75 | 2.73 | .31 | 68.16 |
| Greytown | 10 55 | 83 43 | ........ | 6 | 22.50 | 10.77 | 6.11 | 11.20 | 17.86 | 23.19 | 34.41 | 27.28 | 17.40 | 19.98 | 36.45 | 27.76 | 254.91 |
| Managua | 12 10 | 86 15 | 135 | 3 | .00 | .00 | .00 | .00 | 5.43 | 11.29 | 6.45 | 4.95 | 6.86 | 14.56 | 3.62 | .18 | 53.34 |
| Masaya | 11 58 | 86 5 | 785 | 12 | .14 | .19 | .20 | .28 | 5.58 | 16.53 | 6.62 | 7.49 | 17.06 | 11.00 | 1.96 | .37 | 67.42 |
| Rivas | 11 26 | 85 47 | 150 | 21 | .46 | .20 | .15 | .26 | 8.19 | 11.83 | 7.20 | 8.07 | 10.17 | 17.38 | 4.58 | 1.27 | 69.76 |
| Sabalos | 11 2 | 84 22 | ........ | 3 | 6.26 | 4.06 | 2.16 | 3.07 | 8.58 | 12.28 | 17.84 | 14.65 | 12.24 | 11.61 | 9.02 | 8.11 | 109.88 |
| San Antonio | 12 35 | 87 3 | 66 | 6 | .04 | .07 | .30 | .30 | 10.43 | 12.53 | 8.83 | 9.15 | 13.65 | 20.48 | 3.58 | .22 | 79.58 |
| Valle Menier | 11 46 | 86 3 | 490 | 4 | .09 | .00 | .00 | .05 | 7.41 | 10.31 | 5.91 | 7.44 | 6.87 | 17.74 | 5.13 | .20 | 61.15 |
| COSTA RICA. | | | | | | | | | | | | | | | | | |
| Boca Banana | 9 55 | 83 0 | ........ | 7 | 12.91 | 6.46 | 7.64 | 10.93 | 7.52 | 5.98 | 12.28 | 13.31 | 5.00 | 6.54 | 11.46 | 12.95 | 112.98 |
| Juan Vinas | 9 53 | 83 48 | 3,410 | 6 | 8.94 | 3.07 | 2.56 | 4.84 | 8.50 | 8.03 | 8.50 | 8.35 | 5.94 | 8.23 | 8.23 | 10.47 | 85.66 |
| La Verbena | ........ | ........ | 3,740 | 6 | .32 | .16 | .35 | 1.18 | 7.68 | 12.56 | 9.49 | 7.52 | 11.50 | 14.80 | 8.46 | 2.20 | 76.22 |
| Limon | 10 0 | 83 5 | ........ | 7 | 14.57 | 6.45 | 7.06 | 10.62 | 8.50 | 6.22 | 16.87 | 12.23 | 5.69 | 5.01 | 11.86 | 16.64 | 121.72 |
| Ochoa | 10 48 | 84 10 | ........ | 3 | 12.09 | 8.86 | 7.13 | 7.87 | 13.74 | 16.14 | 22.76 | 18.70 | 15.75 | 8.15 | 19.25 | 18.50 | 168.94 |
| Peralta | 10 1 | 83 37 | 1,090 | 6 | 9.28 | 6.21 | 7.27 | 8.58 | 14.06 | 13.40 | 11.86 | 12.69 | 10.18 | 12.09 | 13.56 | 16.31 | 135.49 |
| San Carlos | 10 13 | 84 29 | 525 | 6 | 9.37 | 6.14 | 4.88 | 5.39 | 11.38 | 13.23 | 16.50 | 14.25 | 12.52 | 17.09 | 19.13 | 14.73 | 144.61 |
| San Francisco Guadelupe | 9 58 | 84 2 | 3,895 | 7 | .79 | .16 | .75 | 2.09 | 8.15 | 11.57 | 10.28 | 8.62 | 11.50 | 12.24 | 6.46 | 1.26 | 73.87 |
| San Jose | 9 56 | 84 7 | 3,760 | 34 | .60 | .18 | .77 | 1.76 | 9.04 | 9.53 | 8.27 | 9.53 | 12.04 | 11.78 | 5.75 | 1.59 | 70.84 |
| Sarapiqui | 10 15 | 84 8 | 2,750 | 6 | 19.56 | 9.28 | 6.37 | 10.67 | 19.41 | 21.10 | 19.36 | 18.26 | 14.21 | 22.66 | 29.94 | 18.62 | 209.45 |
| Siquirres | 10 6 | 83 35 | 197 | 5 | 16.08 | 8.48 | 7.82 | 12.45 | 8.44 | 9.35 | 10.03 | 10.17 | 5.49 | 7.68 | 11.36 | 15.22 | 122.57 |
| Tres Rios | 9 55 | 84 15 | 4,260 | 14 | .35 | .12 | .28 | 2.05 | 7.28 | 11.26 | 7.99 | 9.09 | 8.86 | 15.51 | 6.18 | 1.93 | 70.90 |
| Turrialba | 9 50 | 83 45 | 2,035 | 7 | 8.86 | 2.24 | 2.80 | 7.68 | 8.11 | 11.77 | 10.63 | 10.55 | 9.57 | 9.21 | 7.32 | 15.79 | 104.53 |
| CANAL ZONE. | | | | | | | | | | | | | | | | | |
| Balboa | ........ | ........ | ........ | 23 | 1.00 | .69 | .74 | 3.82 | 7.83 | 7.20 | 7.90 | 7.79 | 6.98 | 9.55 | 9.30 | 5.15 | 67.95 |
| Balboa Heights [2] | ........ | ........ | 118 | 24 | .95 | .84 | .72 | 3.00 | 8.24 | 7.46 | 7.64 | 7.97 | 7.75 | 10.32 | 10.35 | 4.12 | 69.36 |
| Culebra | 9 2 | 79 45 | ........ | 31 | 1.47 | .63 | .56 | 3.62 | 10.69 | 8.87 | 9.47 | 10.07 | 10.99 | 11.67 | 12.23 | 6.57 | 86.84 |
| Frijoles | ........ | ........ | ........ | 10 | 1.79 | 2.19 | .57 | 4.61 | 10.65 | 10.42 | 11.59 | 10.83 | 11.57 | 16.10 | 15.95 | 5.50 | 101.77 |
| Gamboa | 9 10 | 79 50 | ........ | 39 | 1.64 | .95 | .69 | 3.57 | 10.50 | 9.70 | 10.26 | 11.80 | 10.44 | 13.05 | 11.79 | 6.40 | 90.79 |
| Gatun | ........ | ........ | ........ | 17 | 2.88 | 2.59 | 1.92 | 5.59 | 13.27 | 12.35 | 11.98 | 14.40 | 10.07 | 16.18 | 19.15 | 9.62 | 120.00 |
| Rio Grande | ........ | ........ | ........ | 17 | 1.02 | .62 | .35 | 3.34 | 10.07 | 9.12 | 9.73 | 9.33 | 10.64 | 12.77 | 11.20 | 5.03 | 83.22 |
| PANAMA. | | | | | | | | | | | | | | | | | |
| Alhajuela | ........ | ........ | ........ | 22 | .96 | .76 | .45 | 3.54 | 11.51 | 12.06 | 13.07 | 12.49 | 11.45 | 14.89 | 13.75 | 5.52 | 100.45 |
| Colon [3] | 9 22 | 79 55 | 25 | 51 | 3.69 | 1.62 | 1.57 | 4.35 | 12.48 | 13.39 | 15.89 | 15.07 | 12.51 | 14.94 | 21.02 | 11.32 | 127.85 |
| Porto Bello | ........ | ........ | ........ | 10 | 5.85 | 3.54 | 2.08 | 7.73 | 15.90 | 16.08 | 18.04 | 21.04 | 12.74 | 13.68 | 26.48 | 16.84 | 160.00 |

[1] Santa Rita Plantation. [2] Station at Ancon prior to October 1, 1914. [3] Within Canal Zone.

In addition to the averages of precipitation it is interesting and important to know the variations from month to month and from year to year. This is shown for a number of stations representing practically all regions in Table 8, which gives the monthly amounts for individual years, also the greatest and least monthly amounts during the period of observation.

TABLE 8.—*Monthly and annual precipitation (in inches).*

BELIZE, BRITISH HONDURAS.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1894 | 6.60 | 1.25 | 1.50 | 0.04 | 13.78 | 5.81 | 8.01 | 3.90 | 4.49 | 5.90 | 13.97 | 3.49 | 68.74 |
| 1895 | .99 | 3.34 | .08 | 4.15 | 6.29 | 13.64 | 2.62 | 6.70 | 24.07 | 11.55 | 11.64 | 4.75 | 89.82 |
| 1896 | 3.67 | .71 | 4.77 | 2.37 | 3.64 | 10.21 | 14.22 | 6.97 | 2.15 | 6.26 | 17.44 | 4.72 | 77.13 |
| 1897 | 1.81 | 3.73 | 3.60 | 10.63 | 5.14 | 11.31 | 7.81 | 6.31 | 6.22 | 4.87 | 19.80 | 5.99 | 87.22 |
| 1898 | 7.73 | 1.16 | .65 | 2.89 | 2.85 | 26.25 | 4.94 | 13.26 | 16.17 | 13.50 | 6.81 | 3.85 | 100.06 |
| 1899 | 5.87 | 1.44 | 2.17 | 2.04 | 3.11 | 6.88 | 4.39 | 8.00 | 6.19 | 16.00 | 11.58 | 5.70 | 73.37 |
| 1909 | 5.75 | .00 | .00 | 7.00 | .00 | 6.30 | 3.60 | 8.24 | 5.95 | 18.05 | 5.50 | 4.10 | 64.49 |
| 1910 | 6.02 | 2.90 | 7.23 | 1.65 | 12.80 | 4.06 | 6.00 | 5.55 | 5.80 | 5.45 | 5.15 | 1.15 | 63.76 |
| 1911 | 12.58 | 3.80 | 1.45 | 1.30 | 26.39 | 22.40 | 12.39 | 7.65 | 13.85 | 2.70 | 20.12 | 6.30 | 130.93 |
| 1912 | 16.20 | .00 | 3.22 | .10 | 8.40 | 8.70 | 10.22 | 10.37 | 8.10 | 7.29 | 9.33 | 15.52 | 97.45 |
| 1913 | 10.28 | 1.80 | .60 | 8.28 | 7.16 | 7.10 | 13.10 | 6.20 | 13.52 | 30.17 | 15.73 | 12.80 | 126.74 |
| 1914 | 12.58 | 5.40 | .90 | .13 | 2.90 | 12.05 | 5.15 | 5.75 | 10.75 | 13.20 | 18.50 | 10.45 | 97.76 |
| 1915 | 9.40 | 1.15 | 2.60 | .83 | 3.85 | 9.67 | 9.35 | 6.70 | 12.00 | 10.35 | 15.30 | 5.25 | 86.45 |
| Means [1] | 7.44 | 3.22 | 2.47 | 2.23 | 4.91 | 7.86 | 8.23 | 8.27 | 9.38 | 10.58 | 13.29 | 6.65 | 84.53 |
| Greatest | 16.20 | 5.40 | 7.23 | 10.63 | 26.39 | 26.25 | 14.22 | 13.26 | 24.07 | 30.17 | 20.12 | 15.52 | 130.93 |
| Least | .99 | .00 | .00 | .04 | .00 | 4.06 | 2.62 | 3.90 | 2.15 | 2.70 | 5.15 | 1.15 | 63.76 |

COROZAL, BRITISH HONDURAS.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1882 | ..... | ..... | ..... | ..... | ..... | 5.30 | 2.74 | 8.03 | 5.63 | 2.45 | 2.87 | 2.64 | ..... |
| 1883 | 3.22 | 2.41 | 3.99 | 0.31 | 2.01 | 7.93 | 7.05 | 4.50 | 8.12 | 8.15 | 5.80 | 3.58 | 57.07 |
| 1884 | 4.84 | 1.54 | .78 | 2.30 | 4.09 | 4.46 | 7.34 | 5.96 | 4.83 | 14.14 | 5.41 | 2.68 | 58.37 |
| 1885 | 4.10 | .47 | .44 | 2.58 | 2.77 | 3.39 | 1.79 | 2.56 | 3.55 | 7.20 | 2.91 | 1.92 | 33.68 |
| 1886 | .46 | 1.74 | .18 | 1.86 | 10.95 | 3.86 | 11.72 | 4.61 | 13.24 | 3.66 | 6.83 | .81 | 59.92 |
| 1887 | 3.96 | 4.10 | .54 | .52 | 6.81 | 8.19 | 7.15 | 6.52 | 4.55 | 8.74 | 4.27 | 3.79 | 59.14 |
| 1888 | 3.43 | .67 | .80 | 1.68 | 5.29 | 7.52 | 1.12 | 9.06 | 4.58 | 9.76 | 4.40 | .72 | 49.03 |
| 1889 | .76 | 1.07 | 2.31 | 2.49 | 2.56 | 14.22 | 7.87 | 5.63 | 6.75 | 3.96 | 3.97 | 3.69 | 55.19 |
| 1890 | 2.84 | 3.27 | 3.03 | .20 | 5.72 | 8.98 | 3.20 | 3.43 | 9.53 | 4.72 | 7.83 | .30 | 53.05 |
| 1891 | 2.07 | 2.77 | .80 | .33 | 2.30 | 4.61 | 11.23 | 3.74 | 5.92 | 5.10 | 4.08 | 1.89 | 44.84 |
| 1892 | 1.48 | .10 | 1.40 | .00 | 2.88 | 15.05 | 10.68 | 5.57 | 6.00 | 4.76 | 2.31 | 1.38 | 51.59 |
| 1893 | .65 | 1.44 | 1.28 | .20 | 2.96 | 4.87 | 9.87 | 10.21 | 12.04 | 2.10 | 1.45 | 5.09 | 52.16 |
| 1894 | 4.21 | .39 | 1.56 | .17 | 6.38 | 8.60 | 7.75 | 2.52 | 3.65 | 1.84 | 5.59 | 1.07 | 43.73 |
| 1896 | .64 | .79 | 2.01 | .16 | 1.85 | 12.78 | 15.56 | 3.01 | 3.27 | 8.08 | 11.05 | 2.30 | 61.50 |
| 1897 | .80 | .14 | .05 | 2.76 | 3.31 | 14.56 | 4.34 | 9.88 | 3.40 | 17.50 | 7.91 | .45 | 66.48 |
| 1898 | .80 | 1.26 | .39 | 5.76 | 3.75 | 10.58 | 5.94 | 9.73 | 9.06 | 8.62 | 5.74 | 1.22 | 62.85 |
| 1899 | 5.54 | 1.37 | .27 | .48 | .27 | 13.62 | 2.74 | 3.66 | 4.83 | 3.16 | 5.73 | 1.28 | 42.95 |
| Mean | 2.57 | 1.47 | 1.24 | 1.36 | 3.99 | 8.74 | 6.95 | 5.80 | 6.41 | 6.70 | 5.19 | 2.05 | 52.47 |
| Greatest | 5.54 | 4.10 | 3.99 | 5.76 | 10.95 | 15.05 | 15.56 | 10.21 | 13.24 | 17.50 | 11.05 | 5.09 | 66.48 |
| Least | .46 | .10 | .05 | .00 | .27 | 3.39 | 1.12 | 2.52 | 3.27 | 1.84 | 1.45 | .30 | 33.68 |

[1] 24-year period.

CHIMAX, GUATEMALA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | 3.09 | 2.22 | 2.94 | 3.98 | 8.97 | 10.87 | 6.84 | 8.78 | 9.09 | 9.56 | 11.22 | 6.01 | 83.57 |
| 1898 | 3.54 | 3.11 | 1.89 | 4.45 | 14.65 | 11.06 | 10.35 | 12.64 | 9.80 | 27.09 | 8.58 | 9.68 | 116.84 |
| 1899 | 8.05 | 3.41 | 8.69 | 4.47 | 4.28 | 7.05 | 8.97 | 8.33 | 10.40 | 19.81 | 8.88 | 5.13 | 97.47 |
| 1900 | 5.53 | 8.22 | 6.04 | 6.59 | 9.80 | 7.48 | 14.99 | 6.48 | 12.63 | 13.66 | 9.92 | 7.76 | 109.10 |
| 1901 | 6.51 | 4.06 | 4.41 | 1.15 | 4.62 | 17.80 | 10.35 | 7.54 | 10.08 | 16.53 | 5.07 | 9.19 | 97.31 |
| 1902 | 2.77 | 2.60 | 2.80 | 7.28 | 8.95 | 17.74 | 8.22 | 6.10 | 4.22 | 10.66 | 4.66 | 3.41 | 79.50 |
| 1903 | 3.36 | 4.83 | 5.72 | 5.05 | 5.05 | 9.72 | 11.16 | 10.11 | 14.01 | 12.56 | 10.18 | 7.27 | 99.02 |
| 1904 | 8.14 | 5.66 | 5.59 | 9.11 | 13.01 | 17.77 | 13.34 | 9.80 | 8.25 | 14.16 | 5.93 | 6.11 | 116.87 |
| 1905 | 7.71 | 6.44 | 3.32 | 7.02 | 6.51 | 10.55 | 8.60 | 6.92 | 9.34 | 7.83 | 5.73 | 8.42 | 88.39 |
| 1906 | 5.95 | 3.02 | 8.50 | 2.48 | 5.24 | 11.67 | 5.68 | 7.03 | 6.92 | 14.30 | 7.51 | 8.36 | 86.66 |
| 1907 | 4.86 | 4.89 | 1.05 | 2.38 | 6.71 | 4.62 | 9.72 | 6.17 | 9.79 | 7.67 | 4.57 | 6.43 | 68.86 |
| 1908 | 5.53 | 7.93 | 2.26 | 1.08 | 7.70 | 11.72 | 8.59 | 7.35 | 11.07 | 21.02 | 9.44 | 6.19 | 99.88 |
| 1909 | 6.55 | 3.09 | 3.39 | 6.98 | 2.83 | 6.20 | 7.02 | 8.09 | 15.40 | 20.07 | 4.80 | 2.85 | 87.27 |
| 1910 | 10.49 | 6.44 | 6.04 | 7.17 | 7.15 | 14.27 | 7.52 | 7.32 | 11.77 | 11.49 | 3.43 | 5.49 | 98.58 |
| 1911 | 6.93 | 2.96 | .55 | 1.73 | 14.42 | 18.78 | 8.78 | 4.59 | 8.43 | 8.51 | 19.26 | 3.40 | 98.34 |
| 1912 | 8.08 | 1.52 | 5.21 | 1.20 | 8.25 | 12.73 | 8.63 | 5.28 | 6.28 | 9.00 | 17.76 | 8.01 | 91.95 |
| 1913 | 7.94 | 1.02 | 10.22 | 7.21 | 13.92 | 10.67 | 10.51 | 8.31 | 10.65 | 10.26 | 7.24 | 6.46 | 104.41 |
| Mean [2] | 6.00 | 4.22 | 4.54 | 4.28 | 8.28 | 11.85 | 10.11 | 7.96 | 9.88 | 13.54 | 8.63 | 6.68 | 95.97 |
| Greatest | 10.49 | 8.22 | 10.22 | 9.11 | 14.65 | 18.78 | 14.99 | 12.64 | 15.40 | 27.09 | 19.26 | 9.68 | 116.87 |
| Least | 2.77 | 1.02 | .55 | 1.08 | 2.83 | 4.62 | 5.68 | 4.59 | 4.22 | 7.67 | 3.43 | 2.85 | 68.86 |

[2] 20-year period.

EL PORVENIR, GUATEMALA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1898 | 1.14 | 5.86 | 3.66 | 17.99 | 30.98 | 29.17 | 17.28 | 35.47 | 32.40 | 18.50 | 8.28 | 4.49 | 205.22 |
| 1899 | 8.66 | 1.22 | 6.85 | 13.94 | 12.40 | 23.03 | 16.02 | 17.24 | 23.23 | 24.41 | 10.59 | 1.02 | 158.61 |
| 1900 | 2.87 | 6.57 | 5.55 | 15.87 | 25.51 | 27.40 | 41.18 | 9.02 | 21.02 | 31.61 | 9.13 | 2.76 | 198.49 |
| 1901 | 2.44 | 4.33 | 1.69 | 5.83 | 24.06 | 38.90 | 43.54 | 24.49 | 26.77 | 15.24 | 7.48 | 4.80 | 199.57 |
| 1903 | 1.81 | 2.83 | 3.35 | 7.28 | 17.16 | 36.26 | 17.28 | 27.80 | 22.99 | 19.17 | 5.87 | 2.60 | 164.40 |
| 1904 | .79 | 1.40 | 11.89 | 19.09 | 32.28 | 31.42 | 15.67 | 23.35 | 16.87 | 17.54 | 9.82 | 3.66 | 183.78 |
| 1905 | 4.21 | .14 | 16.59 | 16.34 | 26.93 | 22.36 | 11.59 | 14.02 | 19.33 | 23.74 | 6.48 | 4.43 | 166.16 |
| 1906 | 4.98 | 3.37 | 3.92 | 5.02 | 13.19 | 32.76 | 17.64 | 15.94 | 17.28 | 27.56 | 13.70 | 2.79 | 158.16 |
| 1907 | .22 | 9.51 | 4.19 | 4.17 | 16.28 | 22.26 | 17.46 | 11.93 | 12.20 | 12.46 | 11.91 | 2.30 | 124.89 |

TABLE 8.—*Monthly and annual precipitation (in inches)*—Continued.

EL PORVENIR, GUATEMALA—Continued.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1908 | 1.40 | 1.24 | 3.46 | 7.24 | 20.14 | 24.74 | 12.20 | 14.25 | 32.95 | 30.47 | 7.44 | 0.45 | 155.98 |
| 1909 | 1.65 | 1.06 | 1.71 | 14.76 | 17.20 | 25.18 | 18.01 | 31.67 | 35.06 | 21.20 | 1.60 | 2.99 | 172.18 |
| 1910 | .45 | .37 | 5.76 | 6.17 | 27.74 | 24.78 | 15.98 | 20.91 | 23.42 | 22.18 | 7.70 | 1.14 | 156.60 |
| 1911 | 3.86 | 1.26 | 2.95 | 7.99 | 23.82 | 26.12 | 12.15 | 22.78 | 18.90 | 19.02 | 7.11 | 1.10 | 147.06 |
| 1912 | 1.08 | .73 | .26 | 4.80 | 16.06 | 25.79 | 9.74 | 15.04 | 24.61 | 24.15 | 10.33 | 3.85 | 136.44 |
| Mean | 2.54 | 2.85 | 5.13 | 10.46 | 21.70 | 27.87 | 18.98 | 20.28 | 23.29 | 21.88 | 8.40 | 2.74 | 166.12 |
| Greatest | 8.66 | 9.51 | 16.59 | 19.09 | 32.28 | 38.90 | 43.54 | 35.47 | 35.06 | 31.61 | .1370 | 4.80 | 205.29 |
| Least | .22 | .14 | .26 | 4.17 | 12.40 | 22.26 | 9.74 | 9.02 | 12.20 | 12.46 | 1.69 | .45 | 124.82 |

GUATEMALA, GUATEMALA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1850 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 7.01 | 17.87 | 1.38 | 3.23 | ..... |
| 1851 | .39 | 0.00 | 1.42 | 0.43 | 9.06 | 14.21 | 22.64 | 11.81 | 13.23 | ..... | ..... | ..... | ..... |
| 1856 | .12 | .00 | .23 | .47 | 5.35 | 13.98 | 11.74 | 12.17 | 10.99 | 6.85 | .55 | .53 | 62.98 |
| 1857 | .18 | .02 | .58 | 2.09 | 5.31 | 13.27 | 11.72 | 11.11 | 5.39 | 3.53 | 1.08 | .24 | 54.52 |
| 1858 | .50 | .02 | 1.66 | 1.87 | 5.76 | 12.84 | 11.24 | 4.49 | 8.38 | 3.24 | .07 | .10 | 50.17 |
| 1859 | .39 | .13 | 1.94 | 2.30 | 8.06 | 10.07 | 5.95 | 8.81 | 11.42 | 9.48 | .51 | .19 | 59.25 |
| 1860 | .15 | .07 | .10 | 2.03 | 3.26 | 6.41 | 7.02 | 9.26 | 9.36 | 9.82 | .10 | .74 | 48.32 |
| 1861 | .12 | .15 | .52 | 6.87 | 8.15 | 12.86 | 13.14 | 9.13 | 9.50 | 9.96 | .63 | .66 | 71.69 |
| 1862 | .48 | .07 | .00 | .00 | 3.31 | 12.57 | 8.22 | 11.06 | 8.01 | 4.02 | .11 | .13 | 47.98 |
| 1863 | .37 | .03 | 1.52 | .36 | 7.30 | 10.34 | 6.46 | 3.90 | 5.93 | 3.81 | 2.59 | .14 | 42.75 |
| 1864 | .18 | .75 | .04 | 1.09 | 2.57 | 11.67 | 5.35 | 8.10 | 9.56 | 9.54 | .51 | .41 | 49.77 |
| 1879 | ..... | ..... | .28 | 2.53 | 3.02 | 10.72 | 15.56 | 10.52 | 9.66 | 7.37 | .43 | .14 | ..... |
| 1880 | .37 | .22 | .06 | .79 | 5.68 | 9.95 | 5.40 | 9.20 | 9.08 | 6.26 | 2.35 | .07 | 49.43 |
| 1881 | 1.66 | .03 | .01 | .46 | 2.84 | 10.26 | 7.29 | 9.60 | 10.70 | 8.93 | 1.41 | .00 | 53.19 |
| 1882 | .01 | .14 | .00 | 2.24 | 3.07 | 6.68 | 2.86 | 11.46 | 14.06 | 8.24 | .72 | .00 | 49.48 |
| 1883 | .00 | .67 | .91 | .43 | 2.95 | 12.76 | 9.57 | 4.41 | 11.33 | 7.40 | 1.77 | .16 | 52.36 |
| 1885 | .00 | .32 | .00 | .51 | 4.65 | 9.45 | 4.88 | 6.22 | 5.51 | 7.44 | 2.64 | .00 | 41.62 |
| 1892 | .00 | .08 | .47 | .00 | 14.65 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1894 | .00 | .00 | .08 | 2.72 | 7.80 | 10.35 | 2.83 | 3.31 | 8.42 | 4.61 | 1.26 | .16 | 41.54 |
| 1895 | .00 | .04 | .00 | .00 | 5.75 | 8.07 | 3.54 | 8.31 | 8.54 | 3.35 | .47 | .04 | 38.11 |
| 1896 | .04 | .00 | 3.35 | .12 | 4.53 | 11.06 | 9.76 | 1.22 | 11.46 | 3.94 | .71 | .08 | 46.27 |
| 1897 | .08 | .00 | .12 | .16 | 8.31 | 15.47 | 4.88 | 11.97 | 5.83 | 6.34 | .28 | .04 | 53.48 |
| 1898 | 1.50 | .05 | .01 | .15 | 6.47 | 13.88 | 9.90 | 10.10 | 9.50 | 4.47 | .21 | .35 | 56.59 |
| 1899 | .50 | .04 | .07 | .64 | 3.32 | 6.89 | 7.06 | 6.05 | 5.95 | 8.90 | 2.52 | .02 | 41.96 |
| 1901 | .06 | .57 | .06 | .28 | 4.27 | 11.39 | 13.83 | 7.70 | 10.96 | 3.20 | .03 | .23 | 52.58 |
| 1902 | .24 | .04 | .04 | 2.24 | 7.47 | 10.57 | 4.81 | 2.96 | 9.51 | 13.10 | 1.74 | .12 | 52.84 |
| 1909 | ..... | ..... | ..... | ..... | 1.60 | 10.33 | 9.85 | 10.40 | 11.57 | 5.15 | .33 | .00 | ..... |
| 1910 | .00 | .00 | .00 | .15 | 5.19 | 11.59 | 6.84 | 7.61 | 9.16 | 4.43 | .00 | .63 | 45.60 |
| 1911 | .65 | .00 | .00 | 3.30 | 12.09 | 12.94 | 3.34 | 7.61 | 9.77 | 6.38 | 2.83 | .10 | 59.01 |
| 1912 | .00 | .00 | .00 | .83 | 1.45 | 6.69 | 2.02 | 3.28 | 5.83 | 4.89 | .00 | .00 | 24.99 |
| 1913 | .50 | .18 | .25 | .34 | 16.85 | 6.95 | 3.69 | 3.50 | 7.56 | 3.54 | .00 | .68 | 44.04 |
| Mean | .30 | .13 | .47 | 1.22 | 6.00 | 10.84 | 7.98 | 7.77 | 9.11 | 6.76 | .94 | .32 | 51.84 |
| Greatest | 1.66 | .75 | 3.35 | 6.87 | 16.85 | 15.47 | 22.64 | 12.17 | 14.06 | 17.87 | 2.83 | 3.23 | 71.69 |
| Least | .00 | .00 | .00 | .00 | 1.45 | 6.41 | 2.02 | 1.22 | 5.39 | 3.20 | .00 | .00 | 24.99 |

LIVINGSTON, GUATEMALA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1909 | ..... | ..... | ..... | ..... | ..... | ..... | 19.32 | 10.66 | 19.76 | 14.64 | 16.75 | 12.68 | ..... |
| 1910 | 25.52 | 12.58 | 6.27 | 4.99 | 15.99 | 13.44 | 20.07 | 22.00 | 20.33 | 11.18 | 9.02 | 14.11 | 174.50 |
| 1911 | 31.15 | 8.87 | 13.39 | 10.14 | 23.60 | 23.54 | 31.30 | 29.87 | 44.13 | 11.53 | 17.18 | 17.12 | 261.82 |
| 1912 | 20.19 | 1.06 | 5.91 | 2.26 | 16.95 | 16.40 | 22.66 | 41.95 | 12.41 | 15.19 | 9.40 | 16.04 | 180.42 |
| Mean | 25.62 | 7.50 | 8.53 | 5.80 | 18.85 | 17.80 | 23.34 | 26.11 | 24.16 | 13.14 | 13.09 | 14.98 | 198.92 |

QUEZALTENANGO, GUATEMALA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1895 | 0.00 | 0.00 | 0.00 | 0.24 | 5.43 | 8.11 | 2.36 | 3.07 | 6.37 | 4.10 | 0.28 | 0.20 | 30.16 |
| 1896 | .00 | .00 | .00 | .08 | 3.17 | 4.39 | 5.47 | 2.86 | 2.98 | 1.67 | 1.10 | .50 | 22.22 |
| 1897 | .00 | .05 | .08 | .95 | 6.91 | 6.47 | 3.02 | 6.17 | 3.22 | 4.00 | .32 | .00 | 31.19 |
| 1913 | .15 | .50 | .00 | 1.10 | 5.00 | 5.77 | 2.17 | 3.35 | 6.43 | 4.39 | .17 | .14 | 29.17 |
| Mean | .04 | .14 | .02 | .59 | 5.13 | 6.18 | 3.26 | 3.86 | 4.75 | 3.54 | .47 | .21 | 28.19 |

SETAL, GUATEMALA

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1900 | 15.75 | 12.20 | 12.72 | 10.35 | 21.22 | 18.45 | 19.45 | 16.06 | 24.76 | 24.09 | 12.72 | 30.2[illegible] | 218.05 |
| 1901 | 17.13 | 7.20 | 11.93 | 9.21 | 9.45 | 36.85 | 20.71 | 20.55 | 26.69 | 39.72 | 13.54 | 28.74 | 241.72 |
| 1902 | 11.57 | 7.83 | 5.71 | 16.26 | 17.99 | 31.34 | 24.21 | 18.35 | 10.08 | 35.83 | 22.87 | 13.42 | 215.46 |
| 1903 | 10.43 | 18.62 | 18.19 | 8.38 | 17.32 | 25.28 | 23.58 | 22.60 | 30.04 | 49.92 | 17.40 | 21.85 | 263.61 |
| 1904 | 28.82 | 11.02 | 6.89 | 15.87 | 19.72 | 22.84 | 19.13 | 15.71 | 16.97 | 24.72 | 18.62 | 15.59 | 215.90 |
| 1905 | 19.88 | 15.35 | 8.94 | 14.25 | 12.05 | 20.43 | 18.35 | 12.80 | 18.98 | 15.79 | 10.59 | 32.80 | 200.21 |
| 1906 | 20.08 | 9.64 | 29.17 | 5.04 | 7.76 | 14.57 | 13.35 | 16.93 | 13.58 | 23.11 | 17.99 | 13.27 | 184.49 |
| 1907 | 9.53 | 12.76 | 1.30 | 1.38 | 9.17 | 10.16 | 16.85 | 18.94 | 15.20 | 14.45 | 11.42 | 23.42 | 144.58 |
| 1908 | 9.49 | 15.63 | 6.97 | 3.74 | 4.09 | 17.05 | 2.24 | 9.09 | 22.05 | 45.67 | 19.57 | 13.78 | 169.37 |
| 1909 | 10.28 | 10.12 | 1.65 | 9.53 | 2.68 | 10.51 | 9.06 | 13.39 | 15.67 | 41.73 | 9.65 | 4.72 | 138.99 |
| 1910 | 15.90 | 20.30 | 9.41 | 6.46 | 5.35 | 21.18 | 7.32 | 8.94 | 27.48 | 17.01 | 10.28 | 8.46 | 158.09 |
| 1911 | 14.78 | 5.43 | .55 | 4.45 | 22.09 | 36.89 | 13.31 | 15.24 | 19.61 | 15.55 | 32.91 | 9.33 | 190.14 |
| 1912 | 14.49 | 8.07 | 3.35 | .79 | 9.45 | 12.09 | 13.66 | 18.54 | 16.34 | 17.36 | 25.43 | 14.45 | 154.02 |
| 1913 | 19.72 | 3.03 | 21.54 | 18.66 | 18.46 | 18.27 | 18.86 | 6.18 | 17.48 | 24.84 | 20.67 | 10.31 | 198.02 |
| Mean [3] | 15.24 | 11.30 | 9.96 | 8.54 | 11.46 | 20.98 | 18.11 | 15.43 | 19.84 | 28.46 | 18.54 | 15.28 | 193.14 |
| Greatest | 28.82 | 20.30 | 29.17 | 18.66 | 22.09 | 36.89 | 24.21 | 22.60 | 30.04 | 49.92 | 32.91 | 32.80 | 263.61 |
| Least | 9.49 | 3.03 | .55 | .79 | 2.68 | 10.16 | 2.24 | 6.18 | 10.08 | 14.45 | 9.65 | 4.72 | 138.99 |

[3] 17-year period.

TABLE 8.—*Monthly and annual precipitation (in inches)*—Continued.

SAN JUANCITO, HONDURAS.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1912 | ..... | ..... | ..... | ..... | ..... | ..... | 10.00 | 6.57 | 7.30 | 7.79 | 2.38 | 3.54 | ..... |
| 1913 | 3.15 | 0.88 | 1.46 | 4.80 | 9.74 | 13.37 | 8.19 | 5.74 | 10.67 | 10.31 | 4.35 | 1.89 | 74.55 |
| 1914 | .92 | 1.52 | 1.20 | 2.64 | 3.45 | 7.07 | 3.75 | 2.27 | 5.81 | 5.72 | 3.98 | 2.22 | 40.55 |
| 1915 | .83 | .72 | 5.87 | 2.51 | 4.86 | 14.49 | 7.22 | 5.94 | 7.97 | 6.76 | 13.17 | 1.72 | 72.06 |
| 1916 | 2.76 | 1.10 | 1.46 | 2.60 | 8.82 | 9.97 | 12.64 | 15.52 | 8.23 | 8.47 | 4.33 | 1.83 | 77.73 |
| 1917 | 2.04 | .35 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Mean | 1.94 | .91 | 2.50 | 3.14 | 6.72 | 11.22 | 8.36 | 7.21 | 8.00 | 7.81 | 5.64 | 2.24 | 65.69 |

SAN SALVADOR, SALVADOR.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1912 | 0.00 | 0.00 | 0.00 | 0.33 | 4.11 | 7.83 | 10.56 | 14.17 | 5.83 | 12.98 | 0.21 | 2.09 | 58.11 |
| 1913 | .00 | .00 | .28 | 3.87 | 5.68 | 9.38 | 9.01 | 13.11 | 11.31 | 17.99 | 1.93 | 1.34 | 73.90 |
| 1914 | .32 | .18 | .00 | .73 | 10.09 | 13.27 | 9.38 | 9.92 | 15.82 | 8.86 | 1.42 | .00 | 69.99 |
| 1915 | .30 | .00 | .02 | 2.19 | 9.49 | 12.31 | 14.58 | 12.11 | 9.20 | 3.53 | 1.31 | 4.64 | 69.68 |
| 1916 | 1.17 | .00 | .00 | 2.12 | 4.48 | 11.73 | 7.64 | 8.73 | 10.18 | 7.76 | 4.71 | .22 | 58.47 |
| 1917 | .00 | .02 | .45 | .40 | 2.69 | 14.02 | 15.24 | 12.14 | 11.55 | 12.89 | .58 | .00 | 69.98 |
| 1918 | .41 | 1.39 | 3.14 | 11.12 | 12.86 | 13.84 | 12.44 | 9.74 | 7.24 | 9.60 | 1.54 | .11 | 83.43 |
| 1919 | .50 | .54 | .00 | 2.20 | 3.45 | 11.47 | 13.81 | 14.17 | 10.78 | 12.09 | 1.63 | .16 | 70.80 |
| 1920 | .06 | .00 | .01 | .00 | 7.39 | 10.66 | 9.94 | 12.39 | 10.44 | 6.09 | 1.29 | .07 | 58.34 |
| Mean [4] | .17 | .21 | .50 | 1.96 | 6.69 | 11.13 | 12.11 | 11.72 | 11.03 | 10.37 | 1.79 | .59 | 68.27 |
| Greatest | 1.17 | 1.39 | 3.14 | 11.12 | 12.86 | 14.02 | 15.24 | 14.17 | 15.82 | 17.99 | 4.71 | 4.64 | 83.43 |
| Least | .00 | .00 | .00 | .00 | 2.69 | 7.83 | 7.64 | 8.73 | 5.83 | 3.53 | .21 | .00 | 58.11 |

[4] 23-year period.

BLUEFIELDS, NICARAGUA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1883 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 3.42 | 8.13 | 12.13 | 17.00 | ..... |
| 1884 | 10.25 | 6.39 | 3.21 | 2.06 | 2.67 | 8.01 | 17.06 | 16.40 | 5.82 | 4.99 | 9.71 | 11.15 | 97.72 |
| 1885 | 1.96 | 1.60 | 2.66 | 2.87 | 5.89 | 13.37 | 19.82 | 11.75 | 8.07 | 2.69 | 7.70 | 3.15 | 81.53 |
| 1886 | 7.28 | 3.94 | 1.63 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1908 | 7.90 | 9.43 | 6.85 | 4.85 | 13.89 | 27.10 | 31.66 | ..... | ..... | 19.90 | 12.56 | 22.27 | ..... |
| 1909 | 7.31 | 8.82 | 3.26 | 2.68 | 6.02 | 21.89 | 32.29 | 16.21 | 7.76 | 20.41 | 14.92 | 17.81 | 159.38 |
| 1910 | 24.46 | 11.41 | 4.05 | ..... | 11.93 | 14.62 | 42.05 | 19.90 | 18.63 | ..... | ..... | ..... | ..... |
| Mean | 9.86 | 6.93 | 3.61 | 3.12 | 8.08 | 17.00 | 28.58 | 16.07 | 8.74 | 11.22 | 11.40 | 14.28 | 138.89 |
| Greatest | 24.46 | 11.41 | 6.85 | 4.85 | 13.89 | 27.10 | 42.05 | 19.90 | 18.63 | 20.41 | 14.92 | 22.27 | 159.38 |
| Least | 1.96 | 1.60 | 1.63 | 2.06 | 2.67 | 8.01 | 17.06 | 11.75 | 3.42 | 2.69 | 7.70 | 3.15 | 81.53 |

GREYTOWN, NICARAGUA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1890 | 26.80 | 6.36 | 5.93 | 18.11 | 4.93 | 46.84 | 52.55 | 35.72 | 8.14 | 24.36 | 25.55 | 41.65 | 296.94 |
| 1891 | 20.30 | 2.57 | 1.95 | 10.40 | 13.78 | 26.95 | 23.57 | 19.49 | 14.16 | 20.21 | 28.15 | 32.74 | 214.27 |
| 1892 | 28.57 | 11.38 | 4.98 | 18.38 | 50.88 | 13.42 | 38.96 | 23.63 | 11.47 | 27.95 | 36.93 | 24.65 | 291.20 |
| 1893 | 17.70 | 7.53 | 3.93 | 9.99 | 2.77 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1898 | 19.44 | 25.17 | 10.16 | 7.82 | 9.37 | 19.52 | 24.63 | 16.38 | 7.24 | 12.50 | 32.35 | 17.06 | 201.64 |
| 1899 | 23.48 | 11.69 | 8.33 | 9.09 | 21.24 | 20.97 | 39.62 | 29.50 | 36.95 | 12.44 | 40.36 | 32.25 | 285.93 |
| 1900 | 21.20 | 10.72 | 7.47 | 4.62 | 22.06 | 11.43 | 27.13 | 38.96 | 26.45 | 22.44 | 55.38 | 18.24 | 266.10 |
| Mean | 22.50 | 10.77 | 6.11 | 11.20 | 17.86 | 23.19 | 34.41 | 27.28 | 17.40 | 19.98 | 36.45 | 27.76 | 254.91 |
| Greatest | 28.57 | 25.17 | 10.16 | 18.38 | 50.88 | 46.84 | 52.55 | 38.96 | 36.95 | 27.95 | 55.38 | 41.65 | 296.94 |
| Least | 17.70 | 2.57 | 1.95 | 4.62 | 2.77 | 11.43 | 23.57 | 16.38 | 7.24 | 12.44 | 25.55 | 17.06 | 201.64 |

RIVAS, NICARAGUA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1880 | 0.00 | 0.00 | 0.00 | 0.00 | 10.23 | 12.58 | 3.62 | 10.48 | 7.95 | 13.83 | 5.02 | 0.67 | 64.38 |
| 1881 | .00 | .00 | .00 | .12 | 5.20 | 13.17 | 8.88 | 6.96 | 7.42 | 24.67 | 10.88 | 1.91 | 79.21 |
| 1882 | .00 | .13 | .00 | .00 | 4.26 | 9.80 | 4.04 | 6.25 | 7.65 | 23.38 | 4.20 | 1.61 | 61.32 |
| 1883 | .28 | .00 | .00 | .14 | 1.00 | 8.07 | 4.87 | 4.34 | 5.78 | 18.25 | 5.70 | 1.34 | 49.77 |
| 1884 | .59 | .09 | .00 | 2.03 | 2.80 | 10.43 | 4.98 | 3.84 | 4.48 | 15.83 | 7.43 | 2.24 | 54.74 |
| 1885 | .04 | .00 | .00 | .00 | 1.78 | 7.27 | 4.81 | 2.76 | 5.40 | 7.88 | 4.36 | .29 | 34.59 |
| 1886 | .23 | .20 | .00 | .17 | 13.00 | 7.87 | 15.00 | 20.80 | 15.30 | 10.40 | 3.75 | .49 | 87.21 |
| 1887 | .90 | .81 | .00 | .00 | 9.17 | 8.18 | 4.10 | 5.03 | 19.42 | 22.47 | 2.50 | 2.31 | 74.89 |
| 1888 | 1.83 | .04 | .00 | .00 | 7.12 | 8.50 | 4.18 | 5.00 | 9.80 | 16.80 | 1.11 | 1.13 | 55.51 |
| 1889 | .00 | .19 | .07 | 1.71 | 11.34 | 11.64 | 7.48 | 12.95 | 9.80 | 24.13 | 3.38 | 1.67 | 84.36 |
| 1890 | .49 | .11 | .94 | .00 | 2.63 | 4.56 | 4.73 | 3.78 | 2.77 | 9.68 | 1.30 | .82 | 31.81 |
| 1891 | .00 | .00 | .00 | .78 | .75 | 24.58 | 4.38 | 4.21 | 12.42 | 14.90 | 2.34 | 1.67 | 66.03 |
| 1892 | .19 | .00 | .00 | .00 | 13.30 | 9.80 | 9.19 | 7.48 | 12.22 | 21.26 | 4.40 | .43 | 78.27 |
| 1893 | .06 | .39 | .00 | .11 | 20.03 | 21.14 | 13.22 | 18.70 | 14.00 | 13.56 | 2.44 | 2.48 | 106.13 |
| 1894 | 2.12 | .24 | .08 | .00 | 7.76 | 6.32 | 3.64 | 4.57 | 4.33 | 14.62 | 3.21 | .43 | 47.32 |
| 1895 | .00 | .08 | .19 | .39 | 8.11 | 11.02 | 5.25 | 3.42 | 8.01 | 8.97 | 2.04 | .20 | 47.68 |
| 1896 | .40 | .08 | .00 | T. | 3.26 | 6.23 | 7.43 | 6.57 | 7.40 | 7.42 | 8.62 | .39 | 47.80 |
| 1897 | .33 | T. | 1.04 | .00 | 21.30 | 24.34 | 6.41 | 12.10 | 17.63 | 33.85 | 5.15 | 1.28 | 123.43 |
| 1898 | 1.07 | .12 | .10 | .00 | 16.17 | 18.95 | 13.65 | 11.85 | 13.99 | 20.83 | 8.19 | 3.14 | 108.06 |
| 1899 | .85 | 1.70 | .65 | .00 | 1.62 | 7.53 | 10.69 | 9.26 | 5.15 | 20.39 | 9.06 | .92 | 67.82 |
| 1900 | .19 | .02 | .11 | .02 | 11.19 | 16.38 | 10.61 | 9.16 | 22.58 | 21.93 | 1.18 | 1.31 | 94.68 |
| Mean | .46 | .20 | .15 | .26 | 8.19 | 11.83 | 7.20 | 8.07 | 10.17 | 17.38 | 4.58 | 1.27 | 69.76 |
| Greatest | 2.12 | 1.70 | 1.04 | 2.03 | 21.30 | 24.58 | 15.00 | 20.80 | 22.58 | 33.85 | 10.88 | 3.14 | 123.43 |
| Least | .00 | .00 | .00 | .00 | .75 | 4.56 | 3.62 | 2.76 | 2.77 | 7.42 | 1.11 | .20 | 31.81 |

SAN ANTONIO, NICARAGUA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1895 | 0.00 | 0.00 | 0.00 | 0.00 | 7.98 | 6.29 | 3.36 | 5.07 | 21.68 | 21.71 | 3.42 | 0.32 | 69.83 |
| 1896 | .00 | .00 | .00 | .20 | 12.20 | 10.50 | 7.54 | 4.71 | 13.39 | 11.22 | 4.76 | .98 | 65.50 |
| 1897 | .00 | .00 | 1.26 | .59 | 18.23 | 14.53 | 6.81 | 13.86 | 10.94 | 31.06 | .98 | .00 | 98.26 |
| 1898 | .24 | .00 | .00 | .00 | 16.00 | 11.60 | 8.37 | 14.85 | 16.71 | 7.60 | 5.64 | .04 | 81.05 |
| 1899 | .00 | .44 | .00 | .00 | 2.12 | 9.82 | 8.08 | 9.60 | 5.50 | 26.85 | 4.81 | .00 | 67.22 |
| 1900 | .00 | .00 | .55 | 1.02 | 6.05 | 22.46 | 18.81 | 6.80 | 13.69 | 24.45 | 1.85 | .00 | 95.68 |
| Mean | .04 | .07 | .30 | .30 | 10.43 | 12.53 | 8.83 | 9.15 | 13.65 | 20.48 | 3.58 | .22 | 79.58 |

TABLE 8.—*Monthly and annual precipitation (in inches)*—Continued.

LIMON, COSTA RICA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1894 | ..... | ..... | 6.30 | 9.68 | 7.16 | 9.25 | 33.94 | 15.55 | 6.46 | 4.76 | 14.37 | 14.72 | ..... |
| 1895 | 15.63 | 2.44 | 5.71 | 6.69 | 10.87 | 7.72 | 25.32 | 16.46 | 8.11 | 7.36 | 7.52 | 41.06 | 154.89 |
| 1898 | [5] 20.83 | 2.16 | 11.38 | 9.37 | 15.55 | 6.89 | 7.76 | [5] 3.90 | [5] 1.42 | 2.99 | 13.62 | 6.22 | 102.09 |
| 1899 | [5] 11.38 | [5] 14.76 | 5.28 | 8.03 | 14.53 | [5] 7.72 | 29.29 | [5] 13.70 | [5] 7.99 | 3.94 | 11.22 | 13.15 | 140.99 |
| 1900 | [5] 7.05 | 8.31 | 9.57 | 10.28 | 3.58 | 3.82 | 8.27 | [5] 25.24 | 10.91 | 3.98 | 8.07 | 13.74 | 112.82 |
| 1901 | 11.97 | 2.83 | 8.42 | 7.60 | 3.78 | 1.30 | 5.08 | 9.29 | 2.20 | 6.42 | 10.16 | 11.18 | 80.23 |
| 1902 | 19.76 | 8.19 | 6.73 | 21.06 | 11.85 | 10.39 | 16.10 | 11.85 | 7.40 | 5.63 | 18.03 | 16.42 | 153.41 |
| 1903 | 15.39 | ..... | 3.07 | 12.28 | .67 | 2.68 | 9.17 | 1.85 | 1.02 | ..... | ..... | ..... | ..... |
| Mean | 14.57 | 6.45 | 7.06 | 10.62 | 8.50 | 6.22 | 16.87 | 12.23 | 5.69 | 5.01 | 11.86 | 16.64 | 121.72 |
| Greatest | 20.83 | 14.76 | 11.38 | 21.06 | 15.55 | 10.39 | 33.94 | 25.24 | 10.91 | 7.36 | 18.03 | 41.06 | 154.89 |
| Least | 7.05 | 2.16 | 3.07 | 6.69 | .67 | 1.30 | 5.08 | 1.85 | 1.02 | 2.99 | 7.52 | 11.18 | 80.23 |

[5] Interpolated.

SAN CARLOS, COSTA RICA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1898 | 9.29 | 10.00 | 4.88 | 5.04 | 11.46 | 13.78 | 16.54 | 13.03 | 13.23 | 13.42 | 15.29 | 6.14 | 132.09 |
| 1899 | 7.72 | 10.74 | 1.81 | 4.13 | 12.24 | 11.73 | 22.83 | 9.88 | 9.72 | 15.94 | 20.86 | 15.03 | 142.63 |
| 1900 | 8.03 | 3.78 | 3.11 | 5.43 | 14.96 | 7.95 | 17.13 | 13.50 | 12.87 | 19.88 | 21.69 | 10.24 | 138.57 |
| 1901 | 11.85 | 2.64 | 3.78 | 4.33 | 3.62 | 17.05 | 13.07 | 17.32 | 10.12 | 22.09 | 21.46 | 6.89 | 134.22 |
| 1902 | 12.40 | 7.13 | 1.97 | 10.35 | 15.75 | 11.22 | 16.77 | 18.11 | 16.93 | 12.01 | 11.85 | 8.66 | 143.15 |
| 1903 | 6.93 | 2.56 | 13.74 | 3.07 | 10.24 | 17.60 | 12.64 | 13.62 | 12.28 | 19.21 | [5] 23.62 | 41.42 | 176.93 |
| Mean | 9.37 | 6.14 | 4.88 | 5.39 | 11.38 | 13.23 | 16.50 | 14.25 | 12.52 | 17.09 | 19.13 | 14.73 | 144.61 |
| Greatest | 12.40 | 10.74 | 13.74 | 10.35 | 15.75 | 17.60 | 22.83 | 18.11 | 16.93 | 22.09 | [5] 23.62 | 41.42 | 176.93 |
| Least | 6.93 | 2.56 | 1.81 | 3.07 | 3.62 | 7.95 | 12.64 | 9.88 | 9.72 | 12.01 | 11.85 | 6.14 | 132.09 |

[5] Interpolated.

SAN JOSÉ, COSTA RICA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1866 | 1.30 | 0.28 | 0.00 | 1.14 | 5.47 | 4.84 | 12.60 | 6.14 | 10.79 | 9.84 | 6.73 | 4.80 | 63.93 |
| 1867 | 3.86 | 2.21 | .38 | 3.86 | 8.23 | 8.11 | 8.43 | 7.48 | 12.36 | 8.39 | 9.61 | .55 | 73.47 |
| 1868 | .00 | .00 | 7.13 | .01 | 3.27 | 5.91 | 4.02 | 5.12 | 8.82 | 15.47 | 5.67 | .67 | 56.09 |
| 1869 | .28 | .00 | .28 | 1.10 | 7.95 | 8.58 | 5.91 | 5.20 | 15.47 | 11.06 | 3.07 | 4.02 | 62.92 |
| 1870 | .04 | .24 | 1.22 | .67 | 13.11 | 10.87 | 9.45 | 11.18 | 9.45 | 10.32 | 7.24 | 1.30 | 75.09 |
| 1871 | 1.10 | .12 | .32 | .51 | 11.42 | 7.99 | 14.33 | 12.09 | 9.65 | 13.11 | 4.49 | .43 | 75.56 |
| 1872 | .12 | .12 | .59 | 1.97 | 9.61 | 10.04 | 7.56 | 14.88 | 15.63 | 19.84 | 5.59 | .83 | 86.78 |
| 1873 | 2.52 | .00 | .12 | 2.80 | 2.52 | 8.07 | 5.71 | 3.35 | 15.24 | 10.32 | 4.76 | .43 | 55.84 |
| 1874 | 1.81 | .04 | .79 | 2.36 | 13.23 | 6.57 | 6.38 | 7.13 | 12.56 | 7.52 | 1.65 | .79 | 60.83 |
| 1875 | .00 | .00 | .00 | 1.10 | 9.92 | 7.09 | 3.66 | 11.57 | 10.98 | 13.35 | .83 | 1.26 | 59.76 |
| 1876 | .55 | .00 | .43 | .24 | 9.72 | 9.33 | 6.02 | 7.56 | 8.11 | 4.61 | 2.76 | 1.10 | 50.43 |
| 1877 | .55 | .00 | .00 | .00 | 9.45 | 6.57 | 8.78 | 6.26 | 10.20 | 3.74 | 4.76 | 3.11 | 53.42 |
| 1878 | .00 | .00 | 1.50 | 1.97 | 3.59 | 7.36 | 8.07 | 5.87 | 12.99 | 9.37 | 8.78 | .79 | 60.29 |
| 1879 | .51 | .00 | 1.77 | 7.56 | 8.66 | 12.99 | 18.11 | 11.14 | 13.82 | 9.09 | 2.40 | .32 | 86.37 |
| 1880 | .32 | .00 | .00 | .59 | 10.00 | 8.27 | 4.09 | 17.17 | 6.50 | 10.94 | 3.62 | .00 | 61.50 |
| 1884 | .00 | .00 | .08 | .32 | .43 | 2.44 | .59 | .67 | 4.41 | 1.89 | 7.44 | 1.22 | 19.49 |
| 1885 | .00 | .00 | .00 | 1.85 | 5.98 | 3.07 | 7.84 | 3.86 | 15.59 | 12.87 | 16.22 | 2.32 | 69.60 |
| 1886 | .00 | .00 | 2.05 | 8.98 | 15.55 | 16.85 | 20.59 | 19.61 | 22.91 | 28.67 | 16.81 | 2.28 | 154.30 |
| 1887 | .00 | .00 | .67 | .28 | 9.96 | 14.16 | 5.61 | 9.40 | 11.24 | 13.16 | 4.93 | 2.07 | 71.48 |
| 1888 | .63 | .71 | .00 | .55 | 7.07 | 10.24 | 5.49 | 5.54 | 15.71 | 10.39 | 2.01 | .87 | 59.21 |
| 1889 | .01 | .08 | 2.91 | 2.41 | 14.57 | 8.08 | 6.06 | 10.76 | 16.89 | 20.48 | 2.45 | .48 | 85.18 |
| 1890 | .87 | .08 | .75 | 2.52 | 10.08 | 11.65 | 15.67 | 10.55 | 8.35 | 7.99 | 2.56 | .71 | 71.78 |
| 1891 | .03 | .01 | .05 | .74 | 4.26 | 7.74 | 8.00 | 9.84 | 12.30 | 15.48 | 5.57 | 1.16 | 65.18 |
| 1892 | .00 | .00 | .13 | .07 | 12.17 | 15.06 | 8.70 | 13.75 | 14.84 | 21.36 | 5.03 | .44 | 91.55 |
| 1893 | .04 | .00 | .02 | .47 | 8.73 | 15.28 | 13.90 | 13.76 | 20.75 | 14.93 | 7.08 | 2.94 | 97.90 |
| 1894 | .04 | .00 | .00 | .99 | 8.00 | 7.83 | 3.90 | 9.76 | 12.80 | 8.54 | 5.82 | .55 | 58.23 |
| 1895 | .15 | .35 | .04 | .86 | 15.12 | 12.36 | 4.76 | 9.92 | 11.50 | 7.32 | 8.35 | 6.02 | 76.75 |
| 1896 | 2.13 | .00 | .04 | 5.20 | 6.57 | 6.50 | 8.23 | 4.88 | 8.15 | 7.87 | 12.16 | 3.03 | 64.76 |
| 1897 | .20 | .00 | .28 | 1.54 | 12.20 | 8.98 | 4.33 | 15.75 | 12.05 | 14.92 | 3.11 | 1.61 | 74.97 |
| 1898 | .35 | .00 | .28 | 1.30 | 8.58 | 15.59 | 8.90 | 13.39 | 13.62 | 11.69 | 4.65 | .08 | 78.43 |
| 1901 | .15 | .34 | .96 | .03 | 5.07 | 11.16 | 15.67 | 13.45 | 17.00 | 18.82 | 7.19 | .99 | 90.83 |
| 1902 | .20 | .68 | .98 | 1.63 | 13.19 | 7.07 | 6.43 | 4.55 | 1.02 | 7.41 | 3.72 | .09 | 46.97 |
| 1903 | .19 | .01 | .11 | .98 | 14.60 | 13.42 | 8.38 | 15.43 | 9.83 | 11.83 | 2.57 | 5.25 | 82.60 |
| 1904 | 2.48 | .68 | 2.16 | 3.09 | 9.22 | 13.98 | 5.12 | 7.11 | 7.99 | 7.99 | ..... | ..... | ..... |
| Mean | .60 | .18 | .77 | 1.76 | 9.04 | 9.53 | 8.27 | 9.53 | 12.04 | 11.78 | 5.75 | 1.59 | 70.84 |
| Greatest | 3.86 | 2.21 | 7.13 | 8.98 | 15.55 | 16.85 | 20.59 | 19.61 | 22.91 | 28.67 | 16.81 | 6.02 | 154.30 |
| Least | .00 | .00 | .00 | .00 | .43 | 2.44 | .59 | .67 | 4.41 | 1.89 | .83 | .00 | 19.49 |

SARAPIQUI, COSTA RICA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1898 | 14.72 | 11.81 | 10.94 | 14.76 | 17.52 | 22.68 | 16.81 | 17.48 | 19.41 | 19.29 | 21.73 | 5.16 | 192.31 |
| 1899 | 8.42 | 12.36 | 3.23 | 5.24 | 15.47 | 18.54 | 22.76 | 16.61 | 9.96 | 22.84 | 24.76 | 20.04 | 180.23 |
| 1900 | 8.31 | 8.31 | 4.02 | 10.55 | 20.34 | 25.35 | 22.76 | 8.86 | 15.71 | 27.76 | 27.40 | 11.81 | 191.18 |
| 1901 | 27.28 | 2.24 | 5.90 | 9.57 | 6.46 | 16.61 | 15.79 | 17.72 | 15.90 | 31.54 | 52.20 | 27.13 | 228.34 |
| 1902 | 42.44 | 16.61 | 5.63 | 17.76 | 27.40 | 22.68 | 21.89 | 30.63 | 18.50 | 7.36 | 23.62 | 28.94 | 263.46 |
| 1903 | 16.22 | 4.41 | 8.50 | 6.14 | 29.25 | 20.75 | 16.18 | ..... | 5.79 | 27.16 | ..... | ..... | ..... |
| Mean | 19.56 | 9.29 | 6.37 | 10.67 | 19.41 | 21.10 | 19.36 | 18.26 | 14.21 | 22.66 | 29.94 | 18.62 | 209.45 |
| Greatest | 42.44 | 16.61 | 10.94 | 17.76 | 29.25 | 25.35 | 22.76 | 30.63 | 19.41 | 31.54 | 52.20 | 28.94 | 263.46 |
| Least | 8.31 | 2.24 | 3.23 | 5.24 | 6.46 | 16.61 | 15.79 | 8.86 | 5.79 | 7.36 | 21.73 | 11.81 | 180.23 |

TABLE 8.—*Monthly and annual precipitation (in inches)*—Continued.

ANCON-BALBOA HEIGHTS,[6] CANAL ZONE.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | 0.43 | 0.33 | 0.05 | 7.77 | 10.68 | 8.57 | 9.01 | 6.43 | 4.83 | 4.35 | 13.57 | 5.52 | 71.54 |
| 1907 | .29 | .04 | T. | T. | 4.44 | 12.64 | 4.28 | 7.46 | 11.14 | 9.26 | 10.51 | 3.46 | 63.52 |
| 1908 | .12 | .24 | .03 | 1.37 | 7.64 | 4.28 | 6.83 | 11.48 | 5.93 | 8.79 | 9.12 | 4.16 | 59.99 |
| 1909 | 2.90 | 2.90 | .18 | 2.92 | 9.10 | 9.90 | 9.01 | 6.84 | 3.86 | 8.77 | 15.14 | 12.39 | 83.91 |
| 1910 | 1.22 | .43 | 1.83 | 3.71 | 9.89 | 8.82 | 9.26 | 12.00 | 4.84 | 8.86 | 4.29 | 10.63 | 75.78 |
| 1911 | .83 | 2.75 | .26 | 6.34 | 11.04 | 3.40 | 5.78 | 7.21 | 6.03 | 10.90 | 7.57 | 1.99 | 64.10 |
| 1912 | T. | .08 | .01 | 2.68 | 10.71 | 5.80 | 10.25 | 6.33 | 8.38 | 17.89 | 6.38 | 3.27 | 71.78 |
| 1913 | .63 | .22 | .43 | .03 | 8.27 | 8.15 | 4.85 | 8.20 | 11.43 | 8.30 | 10.63 | 4.84 | 65.98 |
| 1914 | .32 | .02 | T. | 4.80 | 6.98 | 7.28 | 4.32 | 6.09 | 9.60 | 6.44 | 10.35 | 8.28 | 64.48 |
| 1915 | 2.12 | 2.96 | T. | 5.37 | 6.42 | 2.85 | 6.93 | 15.24 | 3.69 | 10.49 | 7.05 | 3.60 | 66.72 |
| 1916 | 1.41 | 1.48 | .89 | 2.84 | 12.59 | 4.39 | 10.13 | 10.53 | 8.02 | 10.17 | 8.77 | 5.86 | 77.08 |
| 1917 | .13 | .19 | .02 | 2.24 | 5.75 | 7.35 | 10.17 | 7.42 | 11.53 | 6.14 | 13.77 | 4.09 | 68.80 |
| 1918 | 1.78 | T. | 1.25 | 4.52 | 6.75 | 5.20 | 5.13 | 3.84 | 7.03 | 9.16 | 9.61 | .55 | 54.82 |
| 1919 | .28 | T. | T. | 6.43 | 5.21 | 8.93 | 4.75 | 5.82 | 10.84 | 12.11 | 4.97 | 1.81 | 61.15 |
| 1920 | .03 | .00 | .02 | 3.60 | 4.38 | 9.87 | 6.18 | 12.22 | 9.14 | 6.48 | 19.22 | 1.94 | 73.08 |
| 1921 | .88 | 2.37 | 2.98 | 1.19 | 8.60 | 7.86 | 8.07 | 9.51 | 3.27 | 13.86 | 7.11 | 5.19 | 70.89 |
| Mean [6] | .95 | .84 | .72 | 3.00 | 8.24 | 7.46 | 7.64 | 7.97 | 7.75 | 10.32 | 10.35 | 4.12 | 69.36 |
| Greatest [6] | 5.61 | 2.96 | 5.71 | 7.77 | 12.59 | 13.78 | 15.82 | 15.24 | 15.06 | 20.27 | 19.22 | 12.39 | 91.42 |
| Least [6] | .00 | .00 | .00 | .00 | 4.38 | 2.85 | 3.35 | 3.84 | 3.27 | 4.35 | 4.29 | .55 | 45.58 |

[6] 24-year period. Station moved to Balboa Heights October 1, 1914.

GAMBOA, CANAL ZONE.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | 0.94 | 0.20 | 0.00 | 3.23 | 17.44 | 12.64 | 9.10 | 17.20 | 18.82 | 12.80 | 5.91 | 9.05 | 107.33 |
| 1898 | 2.76 | .12 | .00 | 1.42 | 5.32 | 4.65 | 18.43 | 20.16 | 4.10 | 8.70 | 14.57 | 2.40 | 82.63 |
| 1899 | 5.00 | 1.73 | 1.34 | 1.42 | 8.54 | 8.78 | 9.45 | 10.95 | 13.46 | 7.95 | 8.70 | 2.68 | 80.00 |
| 1900 | 1.01 | .16 | .13 | 3.21 | 6.76 | 12.15 | 13.45 | 8.92 | 9.24 | 12.11 | 10.67 | .79 | 78.60 |
| 1901 | .35 | .24 | .20 | .79 | 10.87 | 7.68 | 9.21 | 13.87 | 8.43 | 14.14 | 19.11 | 6.70 | 91.59 |
| 1902 | 13.40 | .16 | 4.37 | 9.49 | 10.92 | 6.30 | 6.26 | 8.43 | 8.90 | 12.91 | 14.38 | 2.24 | 97.76 |
| 1903 | .67 | .12 | .32 | .41 | 11.35 | 11.03 | 13.45 | 12.87 | 9.30 | 14.18 | 11.94 | 13.83 | 99.47 |
| 1904 | 3.35 | 2.27 | 1.91 | 12.00 | 6.71 | 9.71 | 5.01 | 7.01 | 12.43 | 9.51 | 12.01 | 4.54 | 86.46 |
| 1905 | 2.74 | .05 | .41 | 2.94 | 10.72 | 8.59 | 5.77 | 11.58 | 6.65 | 14.85 | 5.49 | 6.68 | 76.47 |
| 1906 | 1.37 | .47 | .16 | 6.44 | 6.22 | 8.04 | 18.71 | 11.33 | 9.42 | 5.08 | 15.92 | 11.68 | 94.84 |
| 1907 | .28 | .29 | .35 | .44 | 5.98 | 9.68 | 7.92 | 12.69 | 14.01 | 13.02 | 10.43 | 2.96 | 78.05 |
| 1908 | .19 | .04 | .50 | 2.65 | 15.29 | 6.15 | 11.43 | 11.84 | 6.28 | 8.90 | 7.32 | 6.92 | 77.51 |
| 1909 | 2.77 | 4.07 | .56 | 5.55 | 15.37 | 9.55 | 11.59 | 7.03 | 7.90 | 16.98 | 28.41 | 12.33 | 122.11 |
| 1910 | 1.24 | 1.80 | 3.12 | 3.85 | 11.09 | 12.08 | 17.00 | 10.66 | 12.24 | 12.90 | 16.90 | 13.11 | 115.99 |
| 1911 | .11 | .71 | .38 | 4.01 | 14.53 | 6.98 | 7.26 | 7.68 | 5.20 | 12.75 | 10.09 | .97 | 70.67 |
| 1912 | .06 | 1.11 | .10 | .77 | 7.94 | 11.64 | 14.27 | 16.64 | 12.75 | 13.60 | 6.56 | 3.63 | 89.07 |
| 1913 | 2.65 | .68 | .08 | 1.07 | 15.13 | 8.02 | 8.06 | 16.45 | 9.48 | 8.71 | 14.13 | 1.82 | 86.28 |
| 1914 | .64 | .23 | .02 | 1.38 | 10.28 | 17.78 | 3.91 | 7.97 | 11.50 | 9.79 | 7.70 | 6.15 | 77.35 |
| 1915 | 1.74 | 2.75 | .02 | 7.09 | 5.10 | 9.01 | 8.03 | 4.51 | 9.91 | 15.93 | 8.37 | 7.00 | 79.46 |
| 1916 | 2.16 | 1.52 | .89 | 6.68 | 12.25 | 8.44 | 9.59 | 12.22 | 11.37 | 13.46 | 9.84 | 4.75 | 93.17 |
| 1917 | .09 | .30 | .26 | 3.96 | 8.14 | 7.82 | 17.75 | 12.62 | 9.93 | 11.21 | 22.05 | 8.31 | 102.44 |
| 1918 | 3.07 | .07 | .54 | 3.16 | 11.45 | 10.12 | 6.51 | 8.59 | 7.60 | 17.25 | 5.86 | 1.25 | 75.47 |
| 1919 | .55 | .21 | .03 | 7.02 | 5.82 | 6.02 | 6.70 | 7.37 | 9.39 | 11.72 | 3.50 | 3.69 | 62.02 |
| 1920 | .05 | .10 | .21 | 1.48 | 7.59 | 7.48 | 14.71 | 8.97 | 12.68 | 24.93 | 13.63 | 3.05 | 94.88 |
| 1921 | .09 | 5.39 | .09 | 1.16 | 5.89 | 12.81 | 11.33 | 15.68 | 10.48 | 11.83 | 5.96 | 4.42 | 86.13 |
| Mean [7] | 1.64 | 0.95 | 0.69 | 3.57 | 10.50 | 9.70 | 10.26 | 11.80 | 10.44 | 13.05 | 11.79 | 6.40 | 90.79 |
| Greatest [7] | 13.40 | 5.39 | 4.37 | 12.00 | 20.47 | 19.45 | 18.71 | 20.16 | 18.82 | 24.93 | 28.41 | 20.87 | 136.19 |
| Least [7] | .00 | .00 | .00 | .00 | 3.35 | 2.89 | 3.27 | 4.51 | 4.10 | 5.08 | 3.50 | .79 | 62.02 |

39-year period.

COLON, PANAMA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | 3.42 | 0.04 | 0.28 | 3.47 | 16.34 | 18.82 | 14.06 | 17.24 | 17.20 | 5.83 | 22.16 | 18.90 | 138.03 |
| 1898 | 5.04 | .35 | 1.58 | 4.72 | 12.83 | 16.38 | 21.89 | 10.91 | 10.24 | 11.38 | 12.28 | 7.95 | 115.55 |
| 1899 | 6.93 | 6.49 | 1.26 | .43 | 13.90 | 6.41 | 27.68 | 14.80 | 16.55 | 15.09 | 14.49 | 9.04 | 133.07 |
| 1900 | 6.06 | .33 | 1.06 | .75 | 12.25 | 11.65 | 16.81 | 17.00 | 9.37 | 16.33 | 20.28 | 4.13 | 116.02 |
| 1901 | 1.28 | .94 | 1.67 | 1.50 | 6.19 | 11.05 | 9.94 | 12.51 | 11.88 | 12.65 | 32.73 | 5.41 | 107.75 |
| 1902 | 19.20 | .59 | 2.33 | 4.46 | 11.10 | 7.00 | 16.81 | 5.78 | 11.06 | 14.24 | 12.18 | 7.10 | 111.85 |
| 1903 | 1.00 | .35 | .96 | 1.65 | 14.74 | 10.91 | 16.73 | 14.25 | 11.61 | 10.04 | 28.30 | 15.75 | 126.29 |
| 1904 | 7.02 | .47 | 1.65 | 11.46 | 11.06 | 15.83 | 14.21 | 11.14 | 13.86 | 8.14 | 26.33 | 7.02 | 128.19 |
| 1905 | 8.42 | 1.13 | .62 | 2.28 | 22.96 | 8.10 | 9.07 | 15.01 | 6.80 | 13.45 | 17.92 | 9.50 | 115.26 |
| 1906 | 1.47 | 1.14 | 1.42 | 4.23 | 10.07 | 14.09 | 19.23 | 18.31 | 12.48 | 13.34 | 26.64 | 15.64 | 138.06 |
| 1907 | 2.47 | 1.37 | 2.16 | 1.06 | 6.33 | 16.89 | 17.86 | 18.89 | 11.72 | 21.99 | 15.37 | 9.36 | 125.47 |
| 1908 | 3.84 | 1.08 | 3.53 | 1.27 | 22.49 | 10.53 | 14.76 | 16.89 | 11.57 | 10.96 | 31.72 | 9.07 | 137.71 |
| 1909 | 10.61 | 1.92 | 1.85 | 3.56 | 7.21 | 17.49 | 12.83 | 15.42 | 16.33 | 19.31 | 42.50 | 34.38 | 183.41 |
| 1910 | 2.94 | 3.58 | 5.46 | 3.30 | 12.09 | 13.63 | 21.07 | 14.93 | 12.05 | 15.65 | 30.04 | 15.20 | 149.94 |
| 1911 | .99 | 1.81 | 1.41 | 3.06 | 17.13 | 15.58 | 14.58 | 11.60 | 11.62 | 16.53 | 15.81 | 2.63 | 112.75 |
| 1912 | .28 | 1.81 | .66 | .75 | 12.03 | 15.90 | 13.13 | 9.87 | 12.23 | 17.65 | 21.81 | 11.47 | 117.59 |
| 1913 | 6.71 | 1.75 | .79 | 2.69 | 22.60 | 11.81 | 15.13 | 17.91 | 9.90 | 18.63 | 16.75 | 6.55 | 131.22 |
| 1914 | 1.35 | 1.32 | .91 | 4.12 | 17.76 | 16.30 | 10.74 | 16.01 | 14.80 | 22.16 | 18.35 | 8.88 | 132.70 |
| 1915 | 3.41 | 12.37 | 1.71 | 10.42 | 7.75 | 16.01 | 20.72 | 12.89 | 13.85 | 21.86 | 22.33 | 9.45 | 152.77 |
| 1916 | 2.33 | 1.96 | 2.68 | 6.25 | 9.38 | 14.28 | 10.44 | 8.34 | 10.41 | 17.59 | 14.08 | 5.71 | 103.45 |
| 1917 | 1.10 | .45 | .76 | 1.87 | 12.11 | 14.37 | 13.58 | 15.79 | 17.67 | 7.87 | 20.49 | 11.66 | 117.72 |
| 1918 | 3.28 | .67 | .41 | 5.34 | 19.26 | 8.56 | 10.36 | 18.85 | 15.34 | 27.07 | 14.23 | 1.90 | 125.27 |
| 1919 | 1.82 | .36 | .61 | 10.95 | 6.95 | 12.08 | 13.60 | 6.77 | 11.74 | 21.94 | 6.63 | 7.37 | 100.82 |
| 1920 | .51 | .54 | 1.08 | 1.72 | 5.48 | 13.29 | 17.58 | 23.04 | 6.81 | 17.16 | 21.27 | 2.06 | 110.54 |
| 1921 | 1.31 | 1.63 | .98 | 7.43 | 13.61 | 15.18 | 10.49 | 18.45 | 11.21 | 8.27 | 19.96 | 6.50 | 115.02 |
| Mean [8] | 3.69 | 1.62 | 1.57 | 4.35 | 12.48 | 13.39 | 15.89 | 15.07 | 12.51 | 14.94 | 21.02 | 11.32 | 127.85 |
| Greatest [8] | 19.20 | 12.37 | 9.17 | 21.73 | 23.00 | 22.00 | 27.68 | 25.43 | 22.99 | 30.32 | 42.50 | 34.38 | 183.41 |
| Least [8] | .28 | .04 | .02 | .43 | 1.63 | 6.41 | .9.07 | 5.78 | 5.35 | 5.83 | 6.63 | .94 | 86.54 |

[8] 51-year period.

TABLE 8.—*Monthly and annual precipitation (in inches)*—Continued.

PORTO BELLO, PANAMA.

| Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | 2.76 | 1.52 | 0.93 | 5.98 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1908 | ...... | ...... | ...... | ...... | 21.03 | 16.99 | 9.98 | 16.98 | 8.59 | 7.28 | 41.73 | 25.72 | ...... |
| 1909 | 20.90 | 6.82 | 3.56 | 12.56 | 9.69 | 17.70 | 26.33 | 13.83 | 13.99 | 8.70 | 45.03 | 58.17 | 237.28 |
| 1910 | 14.05 | 5.89 | 6.32 | 7.14 | 9.30 | 15.25 | 22.80 | 20.71 | 13.15 | 9.54 | 23.08 | 22.89 | 170.12 |
| 1911 | .84 | 6.90 | 2.38 | 6.60 | 19.25 | 18.04 | 14.48 | 22.56 | 17.55 | 13.78 | 24.40 | 2.16 | 148.94 |
| 1912 | .67 | 1.64 | .60 | .54 | 16.65 | 19.77 | 24.21 | 14.15 | 15.03 | 17.01 | 25.82 | 11.52 | 147.61 |
| 1913 | 5.84 | 2.03 | 1.17 | 2.34 | 30.51 | 9.00 | 20.83 | 25.35 | 11.34 | 18.85 | 33.47 | 10.46 | 171.19 |
| 1914 | 2.38 | 2.20 | .98 | 2.66 | 16.22 | 15.08 | 7.90 | 21.30 | ...... | ...... | ...... | ...... | ...... |
| 1919 | 4.31 | 1.58 | 1.18 | 30.21 | 13.86 | 10.04 | 24.23 | 17.76 | 14.37 | 15.71 | 7.74 | 6.46 | 147.45 |
| 1920 | 2.52 | 1.61 | 1.07 | 2.67 | 5.05 | 20.17 | 16.02 | 27.45 | 10.02 | 27.42 | 14.59 | 8.02 | 136.61 |
| 1921 | 4.21 | 5.20 | 2.57 | 6.61 | 17.46 | 18.77 | 13.59 | 30.32 | 10.65 | 4.84 | 31.34 | 9.53 | 155.09 |
| Mean | 5.85 | 3.54 | 2.08 | 7.73 | 15.90 | 16.08 | 18.04 | 21.04 | 12.74 | 13.68 | 26.48 | 16.84 | 160.00 |
| Greatest | 20.90 | 6.90 | 6.32 | 30.21 | 30.51 | 20.17 | 26.33 | 30.32 | 17.55 | 27.42 | 45.03 | 58.17 | 237.28 |
| Least | .67 | 1.52 | .60 | .54 | 5.05 | 9.00 | 7.90 | 13.83 | 8.59 | 7.28 | 7.74 | 2.16 | 136.61 |

For several other stations there are interesting data relative to greatest monthly and annual precipitation; these are combined with those preceding into Table 9.

TABLE 9.—*Greatest amount of precipitation—Monthly and annual (inches).*

| Stations. | Length of record (years). | Greatest monthly amount. | Month. | Year. | Greatest annual amount. | Year. |
|---|---|---|---|---|---|---|
| Belize | 13 | 30.17 | Oct | 1913 | 130.39 | 1911 |
| Corozal | 16 | 17.50 | Oct | 1897 | 66.48 | 1897 |
| Chimax | 17 | 27.09 | Oct | 1898 | 116.84 | 1898 |
| El Porvenir | 14 | 43.54 | July | 1901 | 205.22 | 1898 |
| Guatemala | 29 | 22.64 | July | 1851 | 71.69 | 1861 |
| Livingston | 3 | 44.13 | Sept | 1911 | 261.82 | 1911 |
| Magdalena | 7 | 11.28 | June | 1917 | 51.65 | 1916 |
| Quezaltenango | 4 | 8.11 | June | 1895 | 31.19 | 1897 |
| Samac | 17 | 51.93 | Nov | 1911 | 220.99 | 1913 |
| San Francisco Miramar | 12 | 49.00 | Sept | 1909 | 238.78 | 1909 |
| San Luis | 11 | 40.61 | Sept | 1916 | 234.10 | 1909 |
| Setal | 14 | 49.92 | Oct | 1903 | 263.61 | 1903 |
| San Salvador | 9 | 17.99 | Oct | 1913 | 83.43 | 1918 |
| Santa Tecla | 8 | 24.94 | Aug | 1886 | 87.49 | 1892 |
| Bluefields | 5 | 45.02 | July | 1910 | 159.38 | 1909 |
| Granada | 10 | 30.79 | June | 1897 | 93.62 | 1897 |
| Greytown | 6 | 55.38 | Nov | 1900 | 296.94 | 1890 |
| Masaya | 12 | 23.56 | Oct | 1887 | 78.78 | 1889 |
| Rivas | 21 | 33.85 | Oct | 1897 | 123.43 | 1897 |
| Sabalos | 3 | 20.71 | July | 1898 | 124.25 | 1898 |
| San Antonio | 6 | 31.06 | Oct | 1897 | 98.26 | 1897 |
| Boca Banana | 6 | 33.66 | Dec | 1903 | 139.17 | 1902 |
| Limon | 7 | 41.06 | Dec | 1895 | 154.89 | 1895 |
| Peralta | 6 | 49.45 | Dec | 1903 | 175.63 | 1903 |
| San Carlos | 6 | 41.42 | Dec | 1903 | 176.93 | 1903 |
| San Francisco Guadelupe. | 6 | 19.65 | Sept | 1901 | 97.40 | 1901 |
| San Jose | 34 | 28.67 | Oct | 1886 | 154.30 | 1886 |
| Sarapiqui | 6 | 52.20 | Nov | 1901 | 263.46 | 1902 |
| Siquirres | 5 | 27.56 | Dec | 1903 | 150.43 | 1902 |
| Balboa Heights | 24 | 20.27 | Oct | 1900 | 91.42 | 1901 |
| Gamboa | 39 | 28.41 | Nov | 1909 | 136.19 | 1887 |
| Colon | 51 | 42.50 | Nov | 1909 | 183.41 | 1909 |
| Porto Bello | 10 | 45.03 | Nov | 1909 | 237.28 | 1909 |

The few data available as to maximum amounts of precipitation in 24 hours are shown in Table 10.

TABLE 10.—*Maximum precipitation in 24 hours.*[1]

| Stations. | Amount. | Date. |
|---|---|---|
| | *Inches.* | |
| Ancon | 7.23 | May 12-13, 1912 |
| Gamboa | 6.56 | Dec. 2- 3, 1906 |
| Gatun | 10.48 | Do. |
| Colon | 8.53 | Do. |
| Porto Bello | 10.86 | Dec. 28-29, 1909 |

[1] For the years 1906-1921, except Porto Bello, 1909-1914 and 1918-1921.

In the wet season the number of days with rain show a maximum generally above 20 and exceeding 25 at some stations; in the *verano* the number is reduced to below 10 at many of the eastern stations, while there are practically none at some of the stations on the Pacific coast.

TABLE 11.—*Average number of days with precipitation.*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belize[1] | 12 | 14 | 7 | 6 | 6 | 8 | 15 | 18 | 18 | 17 | 15 | 16 | 14 | 154 |
| Chimax | 8 | 15 | 11 | 9 | 10 | 6 | 23 | 25 | 24 | 23 | 24 | 19 | 17 | 206 |
| Guatemala | 16 | 4 | 2 | 3 | 5 | 15 | 23 | 21 | 21 | 22 | 18 | 7 | 4 | 145 |
| Las Mercedes | 7 | 3 | 5 | 5 | 10 | 24 | 27 | 27 | 26 | 26 | 26 | 15 | 4 | 198 |
| Quezaltenango | 3 | 0 | 0 | 1 | 3 | 14 | 21 | 17 | 16 | 19 | 17 | 7 | 2 | 117 |
| San Diego | 6 | 1 | 2 | 6 | 9 | 17 | 23 | 12 | 15 | 17 | 16 | 8 | 3 | 129 |
| San Francisco Miramar | 9 | 3 | 2 | 5 | 9 | 18 | 23 | 21 | 20 | 23 | 21 | 12 | 3 | 160 |
| La Laguna | 5 | 0 | 0 | 3 | 6 | 12 | 17 | 21 | 18 | 16 | 10 | 2 | 0 | 105 |
| Mirasol | 5 | 0 | 1 | 4 | 6 | 13 | 14 | 20 | 19 | 17 | 10 | 4 | 0 | 108 |
| San Salvador | 14 | 1 | 1 | 3 | 6 | 15 | 22 | 24 | 23 | 22 | 16 | 7 | 2 | 142 |
| Santa Lucia | 5 | 1 | 0 | 3 | 7 | 15 | 17 | 22 | 19 | 16 | 10 | 4 | 0 | 114 |
| Santa Tecla | 4 | 0 | 1 | 1 | 6 | 16 | 19 | 21 | 24 | 21 | 16 | 6 | 2 | 133 |
| Bluefields | 5 | 18 | 10 | 13 | 14 | 12 | 25 | 31 | 25 | 23 | 18 | 22 | 12 | 223 |
| Masaya | 10 | 1 | 1 | 0 | 1 | 10 | 17 | 16 | 14 | 17 | 18 | 7 | 3 | 105 |
| Rivas | 21 | 4 | 3 | 0 | 1 | 8 | 17 | 13 | 15 | 19 | 22 | 12 | 6 | 120 |
| Boca Banana | 7 | 20 | 15 | 17 | 20 | 17 | 15 | 21 | 21 | 15 | 15 | 19 | 20 | 215 |
| La Verbena | 6 | 2 | 2 | 2 | 4 | 16 | 22 | 20 | 18 | 21 | 24 | 16 | 6 | 153 |
| Limon | 7 | 19 | 11 | 17 | 14 | 14 | 14 | 18 | 21 | 10 | 11 | 15 | 18 | 182 |
| Peralta | 6 | 17 | 10 | 3 | 14 | 10 | 20 | 20 | 24 | 20 | 18 | 22 | 17 | 195 |
| San Carlos | 6 | 18 | 10 | 11 | 19 | 18 | 21 | 26 | 24 | 22 | 29 | 29 | 18 | 245 |
| San Francisco Guadelupe | 9 | 5 | 1 | 2 | 7 | 17 | 22 | 22 | 20 | 22 | 23 | 16 | 6 | 163 |
| San Jose | 14 | 3 | 1 | 2 | 7 | 19 | 22 | 23 | 24 | 24 | 25 | 14 | 6 | 170 |
| Sarapiqui | 5 | 23 | 18 | 14 | 20 | 21 | 20 | 27 | 25 | 24 | 28 | 27 | 21 | 268 |
| Siquirres | 4 | 15 | 8 | 10 | 17 | 16 | 19 | 19 | 15 | 12 | 11 | 20 | 9 | 171 |
| Tres Rios | 13 | 2 | 2 | 2 | 5 | 14 | 18 | 16 | 18 | 20 | 22 | 20 | 6 | 145 |
| Turrialba | 7 | 16 | 10 | 11 | 12 | 19 | 16 | 22 | 18 | 17 | 18 | 18 | 18 | 195 |
| Ancon[1] | 8 | 7 | 5 | 2 | 8 | 20 | 20 | 21 | 20 | 19 | 21 | 23 | 16 | 182 |
| Culebra[1] | 7 | 9 | 7 | 4 | 9 | 21 | 22 | 23 | 24 | 23 | 24 | 25 | 16 | 207 |
| Colon[1] | 6 | 16 | 15 | 16 | 16 | 23 | 24 | 25 | 25 | 24 | 24 | 26 | 23 | 257 |

[1] With 0.01 inch or more. Other values based on 0.1 millimeter (0.004 inch) or more.

*Thunderstorms.*—In the Canal Zone region thunderstorms are frequent in the months from May to November, occurring usually on more than 15 days in each month, while in the remainder of the year they are rare. The same march in frequency is found at San José with the average number of days only 5 for a maximum.

TABLE 12.—*Average number of days with thunderstorm.*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Jose | 11 | 0 | 0 | 1 | 1 | 5 | 3 | 5 | 4 | 5 | 2 | 1 | 0 | 27 |
| Ancon | 8 | 1 | 1 | 0 | 5 | 16 | 18 | 16 | 22 | 19 | 17 | 14 | 5 | 134 |
| Culebra | 7 | 1 | 1 | 0 | 3 | 17 | 20 | 20 | 21 | 19 | 19 | 12 | 4 | 137 |
| Colon | 6 | 1 | 0 | 0 | 2 | 13 | 18 | 17 | 16 | 17 | 14 | 10 | 4 | 112 |

*Relative humidity.*—This element shows a march very similar to that of rainfall. Means range from nearly 90 per cent in the southern region in the wet season to about 70 per cent on the Pacific slope in the dry season. The annual means for these regions are 85 and 75 per cent respectively.

TABLE 13.—*Monthly and annual mean relative humidity (per cent).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belize | 12 | 83 | 79 | 77 | 76 | 78 | 78 | 77 | 78 | 83 | 81 | 84 | 83 | 80 |
| Chimax[1] | 5 | 87 | 84 | 83 | 81 | 85 | 87 | 88 | 87 | 88 | 90 | 89 | 88 | 86 |
| Guatemala[2] | 21 | 72 | 69 | 69 | 70 | 74 | 84 | 82 | 81 | 84 | 82 | 79 | 74 | 77 |
| San Salvador[2] | 9 | 69 | 68 | 68 | 70 | 80 | 85 | 82 | 82 | 85 | 79 | 77 | 72 | 76 |
| Greytown | 3 | 86 | 85 | 81 | 79 | 84 | 87 | 88 | 86 | 86 | 86 | 89 | 87 | 85 |
| San Jose[2] | 12 | 76 | 72 | 72 | 73 | 81 | 84 | 83 | 86 | 86 | 87 | 80 | 80 | 80 |
| Ancon[3] | 8 | 77 | 75 | 72 | 76 | 85 | 87 | 86 | 86 | 87 | 88 | 88 | 83 | 82 |
| Culebra[3] | 7 | 80 | 78 | 75 | 78 | 86 | 88 | 88 | 89 | 88 | 89 | 90 | 86 | 85 |
| Colon[3] | 6 | 80 | 80 | 77 | 80 | 86 | 87 | 87 | 87 | 87 | 87 | 89 | 85 | 84 |

[1] Mean from observations at 6 a. m., noon, and 6 p. m.
[2] Mean from observations at 7 a. m., 2 p. m., and 9 p. m.
[3] Mean from bihourly readings.
Mean for Belize and Greytown probably from early morning and late afternoon observations.

*Cloudiness.*—This has a march practically the same as that for the preceding element, with monthly means 8 or higher, on a scale of 0–10, as maximum in the rainy season and means ranging about 5 for most regions in the dry season.

TABLE 14.—*Monthly and annual mean cloudiness (scale 0–10).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belize | 12 | 5.4 | 4.2 | 4.4 | 4.3 | 5.4 | 6.3 | 6.0 | 5.8 | 6.0 | 6.0 | 6.3 | 5.2 | 5.4 |
| Chimax | 7 | 7.1 | 5.9 | 5.9 | 6.3 | 6.7 | 7.8 | 7.9 | 7.3 | 7.5 | 8.0 | 7.7 | 7.5 | 7.1 |
| San Salvador | 14 | 2.4 | 3.1 | 4.1 | 5.6 | 7.0 | 7.5 | 7.3 | 7.3 | 7.6 | 6.4 | 4.6 | 2.4 | 5.4 |
| San Jose | 5 | 4.1 | 4.6 | 5.7 | 6.5 | 7.9 | 8.0 | 7.1 | 7.7 | 7.8 | 8.3 | 6.5 | 6.0 | 6.7 |
| Ancon | 8 | 5.0 | 5.5 | 5.4 | 6.7 | 8.0 | 8.2 | 7.3 | 7.4 | 7.2 | 7.2 | 7.0 | 6.1 | 6.8 |
| Culebra | 7 | 4.9 | 5.0 | 4.7 | 6.3 | 7.7 | 8.1 | 8.0 | 7.8 | 7.7 | 7.9 | 8.0 | 6.1 | 6.8 |
| Colon | 6 | 4.8 | 4.8 | 4.3 | 5.2 | 6.9 | 7.0 | 7.1 | 6.9 | 6.7 | 6.8 | 7.6 | 5.8 | 6.2 |

*Sunshine.*—The average duration of sunshine varies from slightly over 5 hours a day at San José to nearly 9 hours a day at San Salvador, with extremes of about 3.5 hours in July at the former and 10.5 hours in January at the latter station.

TABLE 15.—*Average duration of sunshine (hours).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Salvador | 14 | 10.4 | 10.3 | 9.6 | 8.5 | 7.7 | 6.6 | 8.2 | 8.8 | 7.5 | 7.7 | 9.2 | 9.9 | 8.7 |
| San Jose | 4 | 7.0 | 8.1 | 7.0 | 6.5 | 5.5 | 3.9 | 3.5 | 4.5 | 4.8 | 3.9 | 5.1 | 4.7 | 5.3 |
| Ancon[1] | 7 | 8.9 | 8.6 | 8.3 | 6.6 | 4.4 | 4.3 | 4.8 | 4.2 | 4.8 | 4.5 | 4.6 | 7.0 | 5.9 |
| Colon[1] | 6 | 8.7 | 8.6 | 8.8 | 8.6 | 6.4 | 5.7 | 5.5 | 5.4 | 5.6 | 4.9 | 4.6 | 6.7 | 6.6 |

[1] Reduced from percentage of possible amount.

*Wind.*—The chief features relative to wind direction are the clockwise shift from about northeast to or somewhat beyond east with the approach of the rainy season over the eastern regions and the marked prevalence of northwest wind on the Pacific coast of the isthmus. Wind movement has a rather well defined march with maximum in February or March and with minimum in June or October. The extremes are about 15 miles an hour at Colon in March and about 4 miles an hour at San José in October. Data on maximum wind velocity are available for no region other than the Canal Zone and vicinity.

TABLE 16.—*Prevailing wind direction.*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. |
|---|---|---|---|---|---|---|---|
| Belize | 11 | ne. | ene, ese. | e, ese. | e, ese. | e. | e, ese. |
| Guatemala | ........ | n, ne. | n, ne. | n, ne. | n, ne. | s, sw. | s, sw. |
| San Salvador | 14 | nw. | s. | s. | sw. | nw. | nw. |
| San Jose | 5 | ne. | ne. | ne. | ne. | e. | e. |
| Ancon | 8 | nw. | nw. | nw. | nw. | nw. | nw. |
| Culebra | 7 | nw. | nw. | nw. | nw. | nw. | nw. |
| Colon | 6 | n, ne. | n, ne. | n. | n. | n. | se. |

| Stations. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|
| Belize | e. | e, ese. | ese. | nw, nnw. | ne, nnw. | ne, nnw. | e. |
| Guatemala | s, sw. | s, sw. | s, sw. | s, sw. | n, ne. | n, ne. | ........ |
| San Salvador | n. | nw. | nw. | s. | nw. | n. | nw. |
| San Jose | e. | ne. | ne. | ene. | ne. | ene. | ne. |
| Ancon | nw. | nw. | nw. | nw. | nw. | nw. | nw. |
| Culebra | nw. | nw. | nw. | nw. | nw. | nw. | nw. |
| Colon | n, se. | se, w. | se. | se. | w. | n. | n. |

TABLE 17.—*Mean wind movement (miles per hour).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Jose | 3 | 11.1 | 12.4 | 10.1 | 9.8 | 5.3 | 4.4 | 5.3 | 4.7 | 4.4 | 4.1 | 6.6 | 8.2 | 7.2 |
| Ancon | 8 | 8.9 | 9.6 | 10.4 | 8.6 | 6.2 | 5.8 | 6.9 | 6.3 | 6.0 | 6.4 | 6.3 | 7.3 | 7.4 |
| Culebra | 5 | 8.4 | 9.3 | 9.8 | 9.1 | 6.0 | 5.0 | 6.4 | 5.8 | 5.3 | 4.9 | 6.1 | 7.8 | 7.0 |
| Colon | 6 | 13.6 | 14.9 | 15.0 | 13.4 | 7.8 | 6.6 | 8.5 | 7.8 | 6.9 | 7.0 | 8.8 | 11.3 | 10.1 |

TABLE 18.—*Maximum wind velocity (miles per hour).*

| Stations. | Length of record (years). | January. | February. | March. | April. | May. | June. |
|---|---|---|---|---|---|---|---|
| Ancon | 8 | 28, nw. | 29, nw. | 30, nw. | 26, n. | 27, se. | 34, s. |
| Culebra | 7 | 30, n. | 33, n. | 35, n. | 31, n. | 28, ne. | 31, s. |
| Colon | 6 | 32, n. | 36, ne. | 36, ne. | 33, ne. | 36, n. | 33, se. |

| Stations. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|
| Ancon | 59, s. | 31, ne. | 31, ne. | 38, se. | 26, se. | 24, nw. | 59, s. |
| Culebra | 39, n. | 40, ne. | 32, ne. | 35, s. | 40, ne | 27, ne. | 40, ne. |
| Colon | 40, s. | 30, s. | 37, w. | 38, sw. | 39, sw. | 38, n. | 40, s. |

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# NOTES, ABSTRACTS, AND REVIEWS.

## HAWAIIAN RAINFALL STATISTICS FOR 1922.[1]

From the published rainfall statistics for Hawaii, 1922, we cull the following interesting information:

The rainfall during the first three months of the year was considerably in excess of the normal; then followed five successive months of deficient rains and the year closed with rainfall about 9 inches below the normal.

The greatest recorded catch, 452.00 inches, was on the summit of Mount Waialeale, Kaui, elevation 5,075 feet[2] and the least 3.18 inches at Olowalu, elevation 10 feet on the leeward shore of Maui. Other points where a catch of more than 300 inches was recorded are, Puu Kukui (upper) Maui, altitude 5,000 feet 346 inches, 103 inches of which is said to have fallen in the single month of January. The catch at Waiakamoi Gulch, Maui, altitude 4,250 ft. was 342.64 inches, which fell in 217 days, or an average of 1.5 inches per day. The rainfall of the Hawaiian Group is almost wholly orographic.

It is only when the northeast trades temporarily weaken or suspend, as happens in the case of the passage of barometric troughs (kona storms), that rain of any consequence falls on the leeward slopes of the islands and this is the explanation of the very small amount registered at Olowalu, as above.—*A. J. H.*

## CONCERNING THE ORIGIN AND DISAPPEARANCE OF SURFACES OF DISCONTINUITY IN THE ATMOSPHERE.

By J. W. SANDSTRÖM.

[Abstracted from *Meteorologische Zeitschrift*, Feb. 1923, pp. 37-39.]

The investigations which have been carried on in the mountains of Sweden have revealed several types of surface of discontinuity, some of which are very obvious and of practical importance, and some of which are easily overlooked. As an example of the former, the clear region bordering the coast which is much utilized by coastwise sailors, is due to the meeting of cold, heavy easterly air with warm, westerly air. The westerly air is underrun by the easterly and an ever-thickening cloud layer is formed which eventually reaches the surface of the sea as a fog bank with an almost vertical front. Other, less-marked, discontinuities occur above valleys in which air has been cooled by radiation and another current of air flows over the top of the valley air. Vague discontinuities occur at the upper surface of a layer of warm surface air in a convective region. After sufficient warm air has accumulated, the ascending column gives rise to very sharp discontinuities between itself and the surrounding atmosphere.

The author has conducted researches relative to the temperature distribution in water under quiet conditions and also when surfaces of discontinuity were formed. The results of these investigations, and also of his meteorological observations, indicate that the relative speed of the two adjacent streams and not the difference in temperature alone determines the degree of sharpness of the surface.

Owing to its geographical situation, Sweden becomes the meeting-ground, in winter, of sharp contrasts in temperature between continental air to the east and oceanic air to the west. With moving cyclones in which these masses of air are converted into rapidly moving streams there frequently appear upon the weather map the phenomena which Bjerknes has related to the Polar Front. But between such moving cyclones, the wind speed is diminished and often it is impossible to trace the surface of discontinuity. Thus, the author

[1] Climatological Data, Hawaii Section, Annual Summary 1922. *Thomas R. Blair, Meteorologist.*
[2] Cf. MO. WEA. REV. 47: 305-308.

feels that the Bjerknesian scheme of the moving waves in the Polar Front is not conclusive.—*C. L. M.*

## DISTRIBUTION OF ICE IN ARCTIC SEAS, 1922.

[Reprinted from *Nature*, London, Mar. 24, 1923, p. 411.]

The publication by the Danish Meteorological Institute of "The State of the Ice in the Arctic Seas, 1922" directs attention to a somewhat unusual year, but unfortunately information is almost entirely lacking from Siberian waters and very scanty from the Beaufort Sea. By April the extent of pack in the Barents Sea was much smaller than usual. Bear Island, which had been free from ice all winter, was clear, and open water almost reached to Nova Zembla. The edge of the ice continued to retreat. In July the whole west coast of Nova Zembla was clear, and in August Franz Josef Land was probably accessible by open sea.

Early in the year conditions in Spitzbergen were about normal. In May and early June an unusual amount of ice drove round the South Cape before continuous easterly winds, but this resulted in the west coast being practically free from ice for the remainder of the summer. On the north coast conditions were particularly favorable, and a vessel reached latitude 81° 29′ N. Some sealers circumnavigated Spitzbergen, a feat that is not possible in most years. In the Greenland Sea the belt of pack lay more westerly than usual, and though the east coast of Greenland does not appear to have been clear of ice, open water touched the coast in about latitude 74° N. during August. Jan Mayen and the coast of Iceland were free from pack from May onward throughout the summer. On the Newfoundland Banks both pack and icebergs were abundant in early spring, but July was clearer than usual. In Davis Strait the winter ice was thinner and the "west ice" less abundant than usual. In Bering Strait conditions were fairly normal, but along the north coast of Alaska the pack pressed hard and navigation was much hindered.

## PREDICTING DROUGHT IN EUROPE.[1]

By F. EREDIA.

[Reprinted from *Science Abstracts*, March 25, 1923, p. 119.]

The author discusses the possibility of forecasting a period of drought some months in advance. Attempts in this direction have not hitherto led to a practical solution of the problem. The method generally adopted is to compare the values of certain meteorological elements, and by means of correlation to deduce from the numerical values of the relative coefficients the connection, intimate or otherwise, between the given elements. Thus some have admitted and others denied the relation between droughts and sunspots, the sun being considered as the primary determinant of all meteorological phenomena. More practical results may be achieved by examining the course of such meteorological elements as are characterized by stability, and of which it is possible to forecast the ulterior direction. Such an element is the barometric pressure.

From an examination of droughts in Italy it is clear that the characteristic barometric distribution is the persistence of anticyclonic areas in the Alpine and adjoining regions. Periods of high pressure coincide with dry periods. Extending our researches to the barometric conditions preceding droughts in the British Isles, it is found that persistent low pressure in the Arctic regions, and especially over Spitzbergen, points to the probable imminence of a dry period. In Italy, with persistent high pressure on the west coast of Europe, and especially on the French Atlantic seaboard, a shortage of rain is almost certain. We are thus led to consider droughts not as isolated phenomena, but as being intimately connected with the atmospheric circulation. The author concludes that we shall be better able to foresee the conditions favorable to the formation of dry periods the more extensive our knowledge of the meteorology of the northern regions, where profound modifications of barometric distribution are first revealed.—*E. F.*

[1] Elettrotecnica, November, 1922, 9: 746-748.

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C. FITZHUGH TALMAN, Meteorologist in Charge of Library.

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C. F. TALMAN, Meteorologist in Charge of Library.

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# SOLAR OBSERVATIONS.

## SOLAR AND SKY RADIATION MEASUREMENTS DURING MARCH, 1923.

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations.

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, **48**:225, and a note in the issue for November, 1922, **50**:595.

From Table 1 it is seen that direct solar-radiation intensities averaged somewhat below the normal values for March at Washington, and close to normal at Madison and Lincoln. An intensity of 1.48 gram-calories per minute per centimeter square measured at Washington at noon on March 29 equals the highest intensity previously measured at that station in March.

Table 2 shows that the total solar and sky radiation Mceived on a horizontal surface averaged above the laarch normal at Madison and Lincoln, and during the rest two weeks of the month at Washington.

Skylight-polarization measurements obtained at Washington on 11 days give a mean of 56 per cent, with a maximum of 63 per cent on the 29th. These are slightly below the average values for Washington for March. At Madison the ground was covered with snow throughout the month, and no measurements were obtained.

TABLE 1.—*Solar radiation intensities during March, 1923.*

[Gram-calories per minute per square centimeter of normal surface.]

**Washington, D. C.**

| Date. | 8 a.m. | 78.7° | 75.7° | 70.7° | 60.0° | 0.0° | 60.0° | 70.7° | 75.7° | 78.7° | Noon. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sun's zenith distance. | | | | | | | | | |
| | 75th meridian time. | Air mass. | | | | | | | | | Local mean solar time. |
| | | A. M. | | | | | P. M. | | | | |
| | e. | 5.0 | 4.0 | 3.0 | 2.0 | [1] 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | e. |
| | *mm.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *mm.* |
| March 2 | 3.45 | | | 0.93 | 1.18 | 1.44 | | | | | 3.99 |
| 3 | 4.75 | | | | 1.01 | 1.28 | 0.89 | | | | 6.02 |
| 7 | 3.99 | | | 0.80 | 1.00 | | | | | | 3.45 |
| 8 | 2.74 | | | 0.71 | 1.09 | 1.43 | 1.07 | 0.89 | | | 1.96 |
| 9 | 2.87 | | | 0.48 | 0.80 | 1.32 | 1.14 | 1.00 | 0.82 | 0.69 | 2.16 |
| 12 | 6.27 | | | | | | 1.07 | 0.90 | 0.72 | 0.58 | 6.76 |
| 14 | 4.75 | 0.57 | | | | | | | | | 3.45 |
| 17 | 2.74 | | | | 1.13 | 1.41 | 1.09 | 0.84 | 0.74 | 0.67 | 2.62 |
| 20 | 1.19 | | 0.93 | 1.07 | 1.21 | 1.48 | 1.19 | 0.98 | 0.86 | | 1.45 |
| 21 | 3.63 | | 0.73 | 1.02 | 1.21 | 1.44 | 1.26 | 1.04 | | | 3.63 |
| 24 | 3.30 | 0.62 | 0.79 | 0.97 | 1.13 | 1.47 | 1.05 | | | | 2.49 |
| 26 | 5.16 | 0.54 | 0.66 | 0.79 | 0.98 | | | | | | 4.57 |
| 27 | 4.17 | | 0.38 | 0.52 | 0.75 | 1.21 | 1.04 | 0.90 | 0.75 | 0.66 | 4.75 |
| 29 | 0.91 | | | | 1.23 | 1.50 | 1.13 | 0.90 | 0.69 | 0.60 | 1.52 |
| 30 | 3.00 | | | | 1.02 | | | | | | 3.99 |
| 31 | 0.91 | 0.98 | 1.06 | 1.21 | 1.34 | 1.52 | | | | | 1.45 |
| Means | | **0.68** | **0.76** | **0.85** | **1.08** | **1.41** | **1.09** | **0.93** | **0.76** | **0.64** | |
| Departures | | **−0.03** | **−0.06** | **−0.10** | **−0.07** | **−0.01** | **−0.03** | **±0.00** | **−0.03** | **−0.04** | |

[1] Extrapolated.

**Madison, Wis.**

| Date. | 8 a.m. | 5.0 | 4.0 | 3.0 | 2.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | Noon. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| March 1 | 3.15 | | | | | | 1.24 | | | | 4.17 |
| 2 | 4.37 | | 0.87 | 1.03 | 1.03 | | | | | | 6.27 |
| 10 | 2.26 | | 1.09 | 1.21 | 1.35 | 1.52 | 1.33 | 1.19 | | | 3.15 |
| 14 | 1.60 | | 1.04 | 1.19 | 1.37 | 1.58 | | | | | 2.16 |
| 16 | 1.19 | | 1.14 | 1.27 | 1.41 | 1.58 | 1.38 | 1.20 | | | 1.24 |
| 19 | 0.51 | | | 1.28 | 1.43 | | | | | | 0.79 |
| 23 | 1.96 | | | 1.03 | 1.24 | | | | | | 2.36 |
| 24 | 1.19 | | 1.11 | 1.22 | 1.34 | 1.46 | | | | | 1.24 |
| 26 | 1.12 | | 1.09 | 1.21 | 1.27 | | | | | | 1.24 |
| 27 | 2.87 | | | | 1.38 | 1.60 | 1.36 | | | | 1.60 |
| 28 | 0.64 | | 1.06 | 1.23 | 1.36 | 1.52 | | | | | 0.71 |
| 30 | 1.32 | | 0.92 | | 1.29 | | | | | | 1.24 |
| 31 | 0.86 | | 1.07 | 1.21 | 1.38 | 1.57 | | | | | 1.19 |
| Means | | | **1.04** | **1.19** | **1.32** | | **1.31** | **(1.20)** | | | |
| Departures | | | **±0.00** | **±0.00** | **±0.00** | | **−0.01** | **+0.04** | | | |

TABLE 1.—*Solar radiation intensities during March, 1923*—Continued.

**Lincoln, Nebr.**

| Date. | 8 a.m. | 78.7° | 75.7° | 70.7° | 60.0° | 0.0° | 60.0° | 70.7° | 75.7° | 78.7° | Noon. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sun's zenith distance. | | | | | | | | | |
| | 75th meridian time. | Air mass. | | | | | | | | | Local mean solar time. |
| | | A. M. | | | | | P. M. | | | | |
| | e. | 5.0 | 4.0 | 3.0 | 2.0 | [1] 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | e. |
| | *mm.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *mm.* |
| March 6 | 3.30 | | 1.11 | 1.22 | 1.38 | | | | | | 3.30 |
| 8 | 3.45 | 0.80 | | | | | | | | | 5.36 |
| 9 | 4.57 | | | 1.10 | 1.30 | 1.56 | | | | | 3.45 |
| 10 | 3.30 | | | | | | 1.26 | 1.12 | 0.93 | 0.84 | 3.00 |
| 16 | 1.19 | | 0.63 | 0.99 | 1.29 | | 1.24 | 1.09 | 0.93 | 0.79 | 2.16 |
| 17 | 3.15 | | 0.86 | 1.05 | 1.22 | 1.41 | | | | | 3.81 |
| 19 | 0.81 | | 1.09 | 1.22 | 1.38 | | | | | | 1.96 |
| 20 | 3.30 | 0.71 | 0.82 | 0.95 | | | | | | | 4.17 |
| 23 | 3.15 | | 0.90 | | 1.28 | | | | | | 4.17 |
| 24 | 3.81 | 0.87 | 1.01 | 1.17 | 1.36 | 1.57 | | | | | 3.81 |
| 26 | 2.49 | | | | | | 1.43 | 1.07 | 0.88 | 0.73 | 3.15 |
| 28 | 2.49 | | 0.95 | 0.98 | 1.23 | 1.55 | | | | | 2.74 |
| 29 | 4.17 | | | | 1.14 | 1.62 | | | | | 4.57 |
| Means | | **0.79** | **0.92** | **1.08** | **1.29** | | **1.30** | **1.08** | **0.91** | **0.78** | |
| Departures | | **−0.07** | **−0.01** | **±0.00** | **±0.00** | | **+0.03** | **±0.00** | **−0.01** | **±0.00** | |

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

| Week beginning. | Average daily radiation. | | | Average daily departure for the week. | | | Excess or deficiency since first of year. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. |
| | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* |
| Feb. 26 | 205 | 233 | 362 | −82 | −51 | +14 | −2,580 | −1,350 | −187 |
| Mar. 5 | 229 | 297 | 371 | −81 | −12 | −2 | −3,144 | −1,437 | −203 |
| 12 | 291 | 300 | 320 | −46 | −31 | −80 | −3,463 | −1,651 | −764 |
| 19 | 379 | 377 | 432 | +23 | +31 | +15 | −3,303 | −1,438 | −661 |
| 26 | 467 | 514 | 584 | +93 | +150 | +158 | −2,649 | −389 | +444 |

# WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

## NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was considerably below the normal at St. Johns, Newfoundland, while at land stations on the American coast, south of Nantucket, small positive departures were the rule, the same conditions holding true at stations on the south coasts of the British Isles. The pressure at Bermuda was considerably above the normal, while at the Azores it was below. The atmospheric conditions over the area between these two localities was rather abnormal during a portion of the month, when the steep gradient was responsible for turbulent weather, which in some cases was accompanied by comparatively high barometric readings. Lerwick, Shetland Islands, was within the limits of an area of high pressure that remained over northwestern Europe from the 14th to 21st, and the high pressure at that station during this period, was responsible for an unusually large positive departure from the normal for the month.

The number of days on which fog was reported was apparently slightly below the normal over the Grand Banks, while it was somewhat above along the American coast, between Hatteras and Canada. Fog was observed on from 2 to 4 days in the Gulf of Mexico, the maximum occurring in the 5-degree square between latitudes 25° and 30° N. and longitudes 90° and 95° W. The middle section of the steamer lanes was, as usual, comparatively free from fog, and it was also rare in the vicinity of the British Isles, although somewhat above the normal in the region between the 15th meridian and the French coast.

The unusually severe weather that has prevailed over the North Atlantic since September, continued in full force during March, although, taking the ocean as a whole, there was a decrease in the number of days with winds of gale force, as compared with February, although they were above the normal for March. The severest weather occurred in the region between the 40th and 45th parallels and 40th and 60th meridians, where gales were reported on from 7 to 10 days. Over that portion of the steamer lanes between the 20th and 40th meridians, the conditions were not far from normal, while the waters adjacent to the European coast were comparatively free from severe weather, due to the long period of anticyclonic conditions referred to above.

The month began with a disturbance off Hatteras, while at the same time the eastern part of the steamer

lanes was covered by an area of low pressure. Charts VIII to XI cover the period from the 2d to 5th inclusive. Storm logs follow:

American S. S. *West Modus*:

Gale began on the 1st, wind SW., 7. Lowest barometer 29.64 inches at 6 p. m. on the 1st, wind, variable, in latitude 28° 40′ N., longitude 65° 19′ W. End on the 2d, wind N. Highest force of wind 9, NW.; shifts SW.-NW.-NNW.

Norwegian S. S. *Niels Nielsen:*

Gale began on the 2d, wind N. Lowest barometer 28.84 inches at 4 a. m. on the 2d, wind N. 20° E., in latitude 42° 24′ N., longitude 55° 03′ W. End on the 3d, wind N., 24° W. Highest force of wind 10; shifts E.-NNW.

American S. S. *City of Freeport:*

Gale began on the 1st, wind SE. Lowest barometer 28.44 inches at 10 p. m. on the 1st, wind NE., 4, in latitude 54° 55′ N., longitude 12° W. End on the 1st, wind NW., 4. Highest force of wind 9, ENE.; shifts NE.-NW.

Danish S. S. *Frederik VIII:*

Gale began on the 5th, wind S. Lowest barometer 28.84 inches at 10 a. m. on the 5th, wind SW. 10, in latitude 51° 30′ N., longitude 31° 05′ W. End on the 6th, wind NW. Highest force of wind 10; shifts S.-SW.

At Greenwich mean noon on the 6th moderate easterly winds prevailed along the American coast from Hatteras to New York that later in the day increased to gale force, as shown by the following storm log.

American S. S. *El Cid:*

Gale began on the 6th, wind E. Lowest barometer 29.04 inches at 8 a. m. on the 6th, wind E, 8, in latitude 40° N., longitude 73° 45′ W. End on the 7th, wind NE. Highest force of wind 10, NE.; shifts not given.

On the 7th the center of this disturbance was near Nantucket, the area between the 30th and 40th parallels, west of the 65th meridian, being swept by moderate to strong westerly to northerly gales. Storm logs:

American S. S. *El Estero:*

At 7 p. m. on the 6th in latitude 30° 25′ N., longitude 79° 38′ W., barometer 29.82 inches, wind SW., 4, weather clear. At 10 p. m. wind had increased to moderate gale from SW. At midnight wind shifted to WNW. 8, squally with rain. 3 a. m. on the 7th ceased raining, wind backing W. 7, weather fine and partly cloudy. Lowest barometer 29.64 inches at 5 a. m. March 7, wind W. 7; in latitude 32° 23′ N., longitude 77° 28′ W.

British S. S. *Araguaya:*

Gale began on the 7th, wind SW. 7. Lowest barometer 29.22 inches at 9 a. m. on the 7th, wind SSW., 11, in latitude 36° 14′ N., longitude 68° 46′ W. End on the 8th, wind WNW. Highest force of wind 11, SW.; shifts SSW.-WSW.

British S. S. *Chickahominy:*

Gale began on the 7th, wind S. Lowest barometer 28.35 inches at 1:30 p. m. on the 7th, wind W., in latitude 42° 24′ N., longitude 66° 30′ W. End on the 8th, wind WNW. Highest force of wind 11; shifts S.-SW.-W.-WNW.

On the 7th there was also an atmospheric depression in midocean, which was of comparatively slight intensity, as the following was the only storm report received from vessels in the vicinity.

American S. S. *Nobles:*

Gale began on the 6th, wind SSW. Lowest barometer 29.67 inches on the 7th, wind SSW., in latitude 43° 15′ N., longitude 30° 55′ W. End on the 7th, wind N. Highest force of wind 9; shifts SSW.-NNW.

On the 8th the western disturbance was central off the west coast of Newfoundland and heavy weather prevailed over the greater part of the region between the 35th and 50th parallels and 35th and 65th meridians. This LOW evidently moved rapidly northeastward, as by the 9th moderate weather was the rule over practically the entire ocean. Storm logs:

British S. S. *Bolivian:*

Gale began on the 7th, wind SW. Lowest barometer 29.00 inches at 4 p. m. on the 7th, wind WSW. 10, in latitude 41° 40′ N., longitude 62° 25′ W. End on the 8th, wind W. Highest force of wind 10; shifts SW.-WSW.-W.-WNW.-W.

British S. S. *Rathlin Head:*

Gale began on the 7th, wind S. Lowest barometer 29.24 inches at 11 p. m. on the 7th, wind SW. 9, in latitude 42° N., longitude 57° 01′ W. End on the 8th, wind WNW. Highest force of wind 10, W.; shifts SW.-W.-WNW.

American S. S. *Texan:*

Gale began on the 8th, wind S. Lowest barometer 29.75 inches at 8 p. m. on the 8th, wind S., 8, in latitude 44° 28′ N., longitude 38° 54′ W. End on the 8th, wind WNW. Highest force of wind 9, S.; shifts S.-WNW.

On the 10th there was a moderate disturbance in mid-ocean that moved rapidly eastward, and on the 12th was central off the coast of Ireland. On the 12th moderate to strong gales were reported from the region between the 40th and 45th parallels and the 35th and 55th meridians. Storm logs:

Dutch S. S. *Amsterdam:*

Gale began on the 10th, wind SW. Lowest barometer 29.60 inches at 3 a. m. on the 10th, wind variable, in latitude 45° 53′ N., longitude 31° W. End on the 12th, wind WNW. Highest force of wind 9; shifts SW.-WNW.

British S. S. *Harperly:*

Gale began on the 11th, wind W. Lowest barometer 29.83 inches at 9 a. m. on the 11th, wind W., 9; in latitude 42° 46′ N., longitude 34° 48′ W. End on the 17th, wind W. Highest force of wind 12; shifts W.-NW.-W.

Danish S. S. *United States:*

Gale began on the 11th, wind W. Lowest barometer 29.68 inches at noon on the 11th, wind W., 10; in latitude 41° 10′ N., longitude 51° 40′ W. End on the 12th, wind NW. Highest force of wind 10, W.; shifts W.-WNW.

British S. S. *Winifredian:*

Gale began on the 11th, wind SW. Lowest barometer 29.34 inches at 6 p. m. on the 11th, wind WSW., in latitude 49° 10′ N., longitude 24° W. End on the 12th, wind NW. Highest force of wind 10; shifts WSW.-W.-WNW.

From the 13th to the 15th a number of vessels in widely scattered locations reported winds of gale force. Storm logs:

American S. S. *Carlton:*

Gale began on the 13th, wind SW. Lowest barometer 30.20 inches at 4 a. m. on the 13th, wind SW., 8, in latitude 38° 08′ N., longitude 56° 15′ W. End on the 21st, wind NE. Highest force of wind 10; shifts SW.-NW.-N.-NE.

British S. S. *Carmania:*

Gale began on the 13th, wind SW. Lowest barometer 29.55 inches at midnight on the 14th, wind SW., in latitude 44° 10′ N., longitude 41° 10′ W. End on the 15th, wind W. Highest force of wind 8; shifts SW.-W.

On the 16th there was a LOW central near latitude 47°, longitude 27°, and at the same time an area of high pressure with its crest near Sable Island, Nova Scotia. While at the time of the Greenwich mean noon observation, moderate winds were reported in the vicinity of the LOW, the region between the 34th and 45th parallels and the 40th and 50th meridians was swept by strong northerly gales accompanied by rain and snow, with barometric readings from 29.85 to 30.30 inches. On the 15th and 16th strong "northers" prevailed in the western part of the Gulf of Mexico. On the 17th the conditions

were similar to those of the previous day, except that the storm area had extended somewhat, as gales with continued high barometric readings were reported by numerous vessels between the 30th and 70th meridians. The HIGH was now central near latitude 40°, longitude 50°, with an area of moderate winds extending about 5 degrees in each direction from the center. By the 17th the "norther" in the Gulf of Mexico had subsided and moderate weather prevailed in these waters. Storm logs:

American S. S. *Independence Hall:*

Gale began on the 16th, wind SW. Lowest barometer 30.10 inches at 2 a. m. on the 16th, wind N., 7, in latitude 37° 30′ N., longitude 44° W. End on the 16th, wind NNW. Highest force of wind 10; shifts N.-NNW.

Dutch S. S. *Moerdijk:*

Gale began on the 15th, wind WNW. Lowest barometer 29.97 inches at midnight on the 15th, wind WNW., 7, in latitude 34° 50′ N., longitude 38° 46′ W. End on the 17th, wind N. Highest force of wind 9, NNW.; shifts NNW.-N.

American S. S. *Alabama:*

At 8 a. m. on the 16th, in latitude 22° 30′ N., longitude 94° 05′ W., barometer 30.03 inches, wind SW., 3.

8.30 a. m. wind shifted to NW., came out with heavy rain squalls, barometer 30.02 inches, wind force, 8.

10 a. m. whole gale, force 10, barometer 30.02 inches.

10 p. m. wind and sea moderating, sky overcast.

Japanese S. S. *Texas Maru:*

Gale began on the 16th, wind S. Lowest barometer 30.05 inches at 10 a. m. on the 17th, wind SW., 9, in latitude 37° 11′ N., longitude 68° 40′ W. End on the 17th, wind N. Highest force of wind 9; shifts S.-SW.

British S. S. *Celtic:*

Gale began on the 14th, wind SSE. Lowest barometer 29.49 inches at 4 a. m. on the 15th, wind WSW., 8, in latitude 44° 41′ N., longitude 39° 55′ W. End on the 16th, wind NW. Highest force of wind 8, NW.; shifts S.-WNW.-NW.

Dutch S. S. *Mijdrecht:*

Gale began on the 16th, wind W. Lowest barometer 29.80 inches at 3 a. m. on the 17th, wind NW., 8, in latitude 33° 30′ N., longitude 34° W. End on the 18th, wind N. Highest force of wind 10; steady NW.

On the 18th, moderate gales were reported by a few vessels in the region between the Azores and Bermudas, while the remainder of the ocean was practically free from heavy winds. On the 19th moderate weather was the rule over the entire ocean except that a second "norther" appeared in the Gulf of Mexico, as shown by the following storm log.

American S. S. *Oswego:*

Gale began on the 18th, wind N. Lowest barometer 29.91 inches at 4 p. m. on the 18th, wind NNW., 4, in latitude 25° 45′ N., longitude 96° W. End on the 19th, wind NNE. Highest force of wind 9, N.; shifts NNW.-N.

On the 20th another disturbance appeared in the vicinity of Newfoundland and westerly gales again swept over the region north of the 35th parallel, west of the 50th meridian. This LOW moved rapidly eastward and on the 21st was near latitude 52° N., longitude 35° W. On that date the storm area extended between the 40th and 52d parallels and the 30th and 45th meridians. It apparently remained nearly stationary, contracting in area from day to day, and by the 24th had practically disappeared. Storm logs:

American S. S. *Antinous:*

Gale began on the 19th, wind SW. Lowest barometer 29.90 inches at 11 a. m. on the 19th, wind SW., 7, in latitude 34° 31′ N., longitude 74° 02′ W. End on the 20th, wind N. Highest force of wind 9, NW.; shifts SW.-NW.

British S. S. *Lapland:*

Gale began on the 20th, wind SW. Lowest barometer 29.32 inches at 1 p. m. on the 20th, wind SW., in latitude 41° 19′ N., longitude 53° 28′ W. End on the 21st, wind NW. Highest force of wind, 9 SW. to W.; shifts SW.-W. after heavy rain squalls.

American S. S. *President Fillmore:*

Gale began on the 21st, wind SW. Lowest barometer 29.12 inches at 4 a. m. on the 21st, wind SW., in latitude 44° N., longitude 40° W. End on the 22d, wind NW. Highest force of wind 9; shifts SW.-NW.

On the 25th there was still another disturbance central near St. Johns, Newfoundland, with a limited storm area between the 40th and 45th parallels and the 43d and 56th meridians. This LOW traveled slowly eastward, spreading out as it moved, and on the 26th, 27th, and 28th gales were prevalent over the middle and eastern sections of the ocean. Storm logs:

American S. S. *West Inskip:*

Gale began on the 24th, wind SW. Lowest barometer 29.46 inches at 4 p. m. on the 25th, wind SW. 8, in latitude 40° 56′ N., longitude 56° 33′ W. End on the 25th, wind NW. Highest force of wind 10; shifts SW.-NW.

British S. S. *Norfolk Range:*

Gale began on the 26th, wind NNW., 7. Lowest barometer 29.74 inches at 3 a. m. on the 27th, wind SSW., 8, in latitude 43°13′ N., longitude 44° 42′ W. End on the 27th, wind NW., 6. Highest force of wind 9; shifts SSW.-SW.

British S. S. *Verbania:*

Gale began on the 26th, wind WSW. Lowest barometer 29.03 inches at 4 a. m. on the 26th, wind W., in latitude 47° 24′ N., longitude 29° 10′ W. End on the 28th, wind W. Highest force of wind 12, SW.; shifts WSW.-NW.

Danish S. S. *Frederik VIII:*

Gale began on the 26th, wind SE. Lowest barometer 28.64 inches at 3 a. m. on the 27th, wind WSW., 10, in latitude 53° 28′ N, longitude 27° 39′ W. End on the 28th, wind W. Highest force of wind 10; shifts SSW.-SW.

British S. S. *Saxoleine:*

Gale began on the 26th, wind SW. Lowest barometer 28.74 inches at noon on the 27th, wind SW., 9, in latitude 56° 28′ N., longitude 25° 12′ W. End on the 29th, wind WNW. Highest force of wind 9, SW.; shifts SSE.-SW.-WNW.

On the 27th, the NE. trades were strongly developed south of Jamaica, as shown by following storm log.

American S. S. *American:*

Gale began on the 26th, wind NE., 7. Lowest barometer 29.83 inches at 7 a. m. on the 27th, wind NE., 7, in latitude 13° 10′ N., longitude 77° 59′ W. End on the 27th, wind NE. Highest force of wind 7, NE.; steady NE.

From the 29th until the end of the month heavy weather was prevalent over the greater part of the ocean, and on the former date gales accompanied by hail and snow occurred north of the 36th parallel, between the 40th and 70th meridians. On the 30th and 31st storm reports were received from vessels in widely scattered localities. Storm logs:

British S. S. *Canadian Leader:*

Gale began on the 28th, wind W. Lowest barometer 29.41 inches at 4:30 p. m. on the 28th, wind W., in latitude 42° 50′ N., longitude 63° W. End on the 29th, wind W. Highest force of wind 10, W.; steady W.

British S. S. *Maine:*

Gale began on the 28th wind S. Lowest barometer 29.58 inches at 8:30 a. m. on the 28th, wind W., in latitude 41° 10′ N., longitude 57° 12′ W. End on the 30th, wind NW. Highest force of wind 11; shifts WSW.-WNW.

British S. S. *Rapidan:*

Gale began on the 29th, wind NW. Lowest barometer 29.65 inches at noon on the 29th, wind WNW., 4, in latitude 40° 56′ N., longitude 47° 07′ W. End on the 30th, wind WNW. Highest force of wind 9; steady WNW.

Danish S. S. *Frederik VIII:*

Gale began on the 29th, wind S. Lowest barometer 29.43 inches at 8 p. m. on the 29th, wind SSE., in latitude 46° N., longitude 38° 21′ W. End on the 30th, wind W. Highest force of wind 11; shifts SSE.-SSW.

Italian S. S. *Georgia:*

Gale began on the 30th, wind SSE. Lowest barometer 29.38 inches at 6.27 a. m. on the 31st, wind SSW., in latitude 36° 56′ N., longitude 65° 03′ W. End on the 31st, wind NNE. Highest force of wind 10; shifts SSW.-W.-NW.-N.

American S. S. *City of Freeport:*

Gale began on the 31st, wind SW. Lowest barometer 29.91 inches at 1 a. m. on April 1, wind SW., 8, in latitude 42° 10′ N., longitude 43° 12′ W. End on April 1, wind W. Highest force of wind 8, SW., shifts SW.-W.

## NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

A considerable amount of cloudy, stormy weather occurred over the North Pacific during March; and among the important disturbances of the month was the typhoon which passed near Guam during the last decade. Over the northern and middle routes the seas were frequently heavy to very rough, and several vessels reported delayed progress in the face of mountainous waves. Wind velocities, however, were not unusually high, and few gales of greater force than 10 were reported.

At Honolulu the weather was unusually windy, with prevailing wind from the east. The average hourly velocity was 9.7 miles. The highest velocity, nevertheless, was only 40 miles, this occurring with an east wind on the 8th, but there were 7 days with velocities in excess of 24 miles. Cloudy skies prevailed and the total precipitation, 6.36 inches, was 3.16 inches above the normal.

It is interesting to note the precipitation conditions along the American coast from San Diego to Juneau. At the California coast stations the rainfall was much below the normal for the month, and at San Diego the percentage of sunshine was the highest ever recorded in March. To the northward of San Francisco precipitation increased, until at North Head it was slightly more than half the normal amount; while at Juneau it was more than double the normal. The total snowfall at Juneau was 39.7 inches, which is the greatest amount of the past 20 years in March, and more than three times the normal.

Of the storms that entered the ocean from the Asiatic continent, most of them seem to have sprung from Mongolia and Siberia. The winter high pressure area overlay eastern China and the adjacent seas during the greater part of the month, and so far as known the only cyclones or depressions of consequence to this region were the two which occurred on the 7th–8th, and on the 10th. Both of these moved northeastward over Japan.

Of the more northern cyclones proceeding from the continent, that of the 2d and 3d gave fresh to whole gales over the sea to the eastward of Japan, and was perhaps the most intense. The British S. S. *Bessie Dollar,* while in and near latitude 34° N., longitude 144° 29′ E., on the 3d, encountered southwesterly to northwesterly gales, force 10, lowest pressure 29.70 inches. On the same day the American S. S. *West Prospect,* while in latitude 34° 39′ N., longitude 146° 18′ E., experienced westerly to northwesterly gales, force 9, lowest pressure 29.65 inches. Several vessels also reported gales from the same locality on the 11th to 14th, accompanied by rain, hail, and tremendous seas, though with only moderately low pressures.

On the 16th to 20th several steamships encountered stormy weather between about latitudes 33° and 50° N., longitudes 160° and 177° E. Among them the American schooner *Bakersfield,* while westward bound in latitude 49° 36′ N., longitude 168° 15′ E., on the 18th, was beset by extraordinarily high seas, raised by a steady northeast gale, highest force 11; the lowest pressure was 29.84 inches. On the same date the Japanese S. S. *Iyo Maru* experienced a steady north-northwest gale, force 10, in latitude 44° 43′ N., longitude 163° 24′ E., and the American S. S. *West Kader* a steady northeast gale, highest force 10, lowest pressure 29.62 inches, in latitude 50° 12′ N., longitude 176° 15′ E. These gales were associated with a storm center in the Aleutian area.

On the 21st a rapidly moving disturbance was central near latitude 45° N., longitude 153° E. The *Bakersfield,* in the vicinity, reported a northeast gale, force 10, lowest pressure 29.48 inches.

On the 31st the lowest pressures of the month occurred, apparently owing to an intensification of a LOW over the western Aleutian area. The condition continued through the following day and into the 2d of April. The lowest observed pressure on the 31st was 28.66 inches, noted in latitude 45° 15′ N., longitude 173° 15′ E., by the American S. S. *Dewey;* but on April 1 the region was swept by storm and hurricane winds, and the low reading of 28.24 inches was observed.

One of the most important storms of the month was the typhoon that passed near Guam on the 25th and 26th. This seems to have appeared as a depression over the central portion of the Caroline Archipelago on the 21st or 22d. It moved eastward, slowly developing, and at 8 p. m. of the 25th (Eastern time) the center was south of Guam, as evidenced by the observation at that point: Wind east, force 9, pressure 29.08 inches. Twenty four hours later the wind at Guam was south, force 6, pressure 29.18 inches; and at 8 p. m. of the 27th, though the wind was light from the south, the pressure was still as low as 29.48 inches. The typhoon did considerable damage on the island. From the Marianas it apparently moved west-northwestward, recurving shortly afterward toward the north and passing to the eastward of the Bonin Islands. On the 29th the U. S. Transport *Meigs* received a radio report of a typhoon in the vicinity of Guam, and while in latitude 32° 47′ N., longitude 140° 23′ E., experienced falling pressure, wind shifting from southeast into east and northeast, and an increasing ocean swell. At 4 p. m. of the 30th, while near latitude 33° N., longitude 144° E., the *Meigs* experienced lowest pressure 29.53 inches, with a fresh northerly breeze and a northeast swell. It is not known whether the typhoon died out at this time or entered the area of disturbance then increasing in energy over the western Aleutians.

Over the eastern waters of the Pacific only one storm of consequence developed in lower latitudes. That seems to have formed near the Hawaiian Islands on the 26th. Honolulu on that date recorded the lowest pressure of the month, 29.76 inches, though without accompanying gale winds. On the 27th, however, this station recorded a maximum wind velocity of 35 miles from the northeast, and several vessels to the eastward were

experiencing increasing winds and falling pressure. On the 28th the storm was moving northward with increased energy, and at noon the American S. S. *West Ivan*, while in latitude 37° 11′ N., longitude 143° 23′ W., observed the lowest pressure reported, 28.97 inches, the wind shortly thereafter increasing to force 10, from the west. During the 28th this cyclone seems to have decreased in energy with northward movement, although westerly winds, force 9, occurred near latitude 37° N., between longitudes 141° and 145° W., during the morning hours. On the two following days what remained of the storm lay off the coasts of Washington and British Columbia, and from it an offshoot depression entered the continent.

Off the coasts of Mexico and Central America generally fine weather prevailed. At least one depression formed in this region, however, and that on the afternoon of the 19th and the morning of the 20th. The American tanker *A. C. Bedford*, while in latitude 14° 35′ N., longitude 95° 50′ W., on the 19th, experienced a northeasterly gale, highest force 9. Early on the 20th the American S. S. *American*, southward bound, experienced a similar gale in 14° 30′ N., 96° 28′ W., lowest pressure 29.86 inches. At 9 a. m. of this date the *American* sighted a "large waterspout without visible movement" in 15° 36′ N., 98° 20′ W.

Over the northern area, that is, within the region embraced by the Gulf of Alaska and the Aleutians, considerable storm activity occurred during the month. The Aleutian LOW showed somewhat the customary double-center formation with more or less shifting along the parallels, but the westernmost center was the stronger and more persistent. Individual offshoots from the LOW in the Alaskan region entered the Canadian Northwest on the 3d, 6th, 10th, 15th, 18th, 21st, 23d, and 27th of the month.

The North Pacific HIGH was well-developed during most of March, and was seriously disturbed only by the storm which began in the Hawaiian region on the 26th.

Pressure was below normal by small amounts over the eastern part of the ocean, as shown by observations at the island stations, the greatest deficiency being in the region of the Hawaiian Islands. The average pressure at Dutch Harbor, based on p. m. reports, was 29.73 inches, 0.04 inch below normal. The highest pressure, 30.34 inches, occurred on the 11th; the lowest, 28.74, on the 8th. Absolute range 1.60 inches. At Honolulu the average p. m. pressure was 29.97 inches, or 0.07 inch below normal. The highest pressure, 30.15 inches, occurred on the 9th; the lowest, 29.76, on the 26th. At Midway Island the average p. m. pressure was 30.09, or 0.01 inch below normal. The highest pressure, 30.36 inches, occurred on the 11th; the lowest, 29.78, on the 29th and 30th.

On the 26th and 27th two vessels, the American S. S. *West Keats* and the Japanese S. S. *Boston Maru*, reported ice floes between latitudes 43° and 44° N., longitudes 145° 47′ and 148° 42′ E. The fields were often several miles apart, and the ice 3 to 5 feet in thickness.

More fog occurred in March than during any of the preceding three months, and it was more generally widespread along the northern and middle latitudes. There was scarcely a day in which it was not reported from some portion of the North Pacific area. In the South Pacific fog was noted on the 23d and 24th from the 7th parallel southward for some distance along the coast of Peru.

## SOUTH PACIFIC CYCLONE OF FEBRUARY-MARCH, 1923.

By WILLIS E. HURD.

The American S. S. *Vinita*, Captain Holsen, observer Chas. H. McKean, while on a voyage from Honolulu toward Auckland, New Zealand, encountered rough weather during the last of February and the 1st of March (Greenwich dates) while near latitude 30° S., and the 180th meridian. On February 27 the vessel received radio warning from Wellington, New Zealand, of a storm central north of Cape Maria and an ocean forecast of east to northeast gales. On the morning of the 28th, while the *Vinita* was in latitude 28° 59′ S., longitude 179° 30′ E. the weather became squally and pressure began falling rapidly. By 2 p. m. the seas were mountainous, with wind from the north, force 8-9, pressure 29.25 inches. At 8 p. m. the sky partly cleared and the weather moderated, with the glass at its lowest, 29.12 inches, in D. R. latitude 30° 20′ S., longitude 178° 05′ E. At 11.15 p. m. the vessel hove to in a southerly wind, buffeted about by cross changing to southerly seas. Shortly after midnight the wind went into the southeast, force 9, and remained in this quarter during the forenoon of March 1, gradually moderating, with rising pressure, so that the vessel was able to resume her course by 9 a. m.

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## NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

*Newfoundland.*—ST. JOHNS, March 15.—The sealing fleet, which sailed from this port for the Grand Banks a week ago is jammed in an immense ice field off the coast of Newfoundland.—*New York Tribune, March 16, 1923.*

ST. JOHNS, March 31.—Service on the Newfoundland Railway suspended because of the blizzard [Mar. 29] has not been resumed as yet. Off the coast the storm is still raging. Many vessels remain frozen in the ice fields, and the sealing fleet reported by radio to-day that it was unable to move owing to the ice pack.—*New York Tribune, March 31, 1923.*

*British Isles.*—Unusually high day temperatures were registered about the 27th. At Kew Observatory, Richmond, a maximum of 68° F. occurred on that date. Such a temperature has only once before been recorded there in March during the past 50 years. * * *

The rainfall of the month was above the average in parts of the south of the British Isles but less than half the average fall in the northern half of Scotland.[1]

*France.*—Early in the month stormy weather with much rain and violent thunderstorms occurred in France, and heavy floods were reported on the Seine, parts of Paris being flooded, and on many other rivers from the 1st to about the 8th. There was some loss of life.[1]

*Asia Minor.*—On the 23d, the Tigris was reported as rising to an unprecedented height in consequence of heavy rains and the melting of snow in Kurdistan; a day or two later it burst its banks, flooding 300 square miles of desert and isolating Baghdad.[1]

*Africa.*—Heavy rains in Nyasaland in the middle of March did great damage to the tobacco crop, and caused destructive floods on the Zambesi on the 19th and 20th, which interrupted railway communications. On the 26th the floods were subsiding.[1]

[1] *Meteorological Magazine*, April 1923, pp. 68-69.

*Australia.*—In Queensland * * * the month was one of drought.[1]

*Guam.*—AGANA, March 30.—A typhoon of moderate intensity struck the island of Guam last Saturday, raged four days and receded without causing loss of life, but leaving property damage estimated at $200,000.—*New York World, March 31, 1923.*

*Argentina.*—In Buenos Aires the unusually high March temperature of 94° F. recorded on the 12th, was followed by a fall of 36° F. in 12 hours. Pressure rose 5 mb. almost instantly.[1]

*Brazil.*— * * * In the north the rainfall averaged 53 mm. below normal. In the center the distribution was irregular; in the south the fall averaged 100 mm. above normal, the excess being greatest in the extreme south. * * * There is still an absence of intense anticyclones and the general circulation presents no unusual features.[1]

# DETAILS OF THE WEATHER IN THE UNITED STATES.

## GENERAL CONDITIONS.

ALFRED J. HENRY.

The single outstanding feature of the month was the steady march of anticyclonic areas from the Pacific, some of which entered the continent north of the mouth of the Columbia and others as far south as the middle California coast.

As a direct result of this movement, drought prevailed in the Pacific Coast States, also in the Plateau region, the northern Rocky Mountains, and the upper portions of the Missouri and Mississippi Valleys; the most striking result, however, was the unseasonable temperatures recorded in many parts of the country due to the transportation of cold air from higher latitudes. Details appear in subsequent pages.

## CYCLONES AND ANTICYCLONES.

By W. P. DAY.

March, in contrast to the preceding month, showed greatly increased barometric activity, a rapid succession of cyclones and anticyclones passing within the range of observation. Twenty low-pressure areas were noted and tracked, nine of which were of the Alberta type (Alaskan or North Pacific cyclones coming into the field of observation from Alberta), but the more important storms began as secondary developments over the south or southwest and several attained major intensity.

Thirteen high-pressure areas—anticyclones—were observed and these incursions of denser air were quite important as cold waves in several instances. The cold-wave types are usually masses of cold air loosed from the cold polar cap which advance southward over Canada when pressure conditions in the United States are favorable. Anticyclones moving in from the Pacific do not bring marked changes to colder.

## FREE-AIR SUMMARY.

By L. T. SAMUELS, Meteorologist.

The general characteristics of the average free-air conditions for the month as a whole showed remarkably close agreement with those for February, 1923, with respect to departures from normal. Thus it will be observed in Table 1 that the temperature departures were all negative except in the upper levels at Groesbeck, a condition identical with that found last month. The persistence of large departures with increase in altitude was likewise most pronounced at the northern stations.

The vapor pressure departures conformed regularly with those for temperature and the relative humidity averaged in general somewhat less than the normal in the lower levels and above in the upper levels, although practically all the departures were less than 10 per cent.

At each of the six kite stations minimum March temperature records were exceeded at various upper levels. These low temperatures were observed as a rule during the prevalence of severe cold wave conditions, a number of which occurred during the month.

In Table 2 are shown the resultant wind velocities and directions for the month and their normal values. A striking feature observed in the table is the high resultant velocities for the month at all stations except Broken Arrow and Groesbeck. The usual connection found between the resultant wind direction and the temperature departures is especially well illustrated. At Drexel and Ellendale where negative temperature departures were greatest the north component is found to exceed the normal by an appreciable amount. At Royal Center, Broken Arrow, and Due West the south component is decidedly less than normal while at Groesbeck, where negative temperature departures occurred in the lower levels and positive departures in the upper levels, the south component was less than normal in the former but exceeded it in the latter.

High winds were frequent during the month, there being more than twice as many observed velocities of 40 meters per second or more as occurred during March, 1922. These were observed by means of pilot balloons and are given in the following table:

| Station. | Date. | Velocity. | Direction. | Altitude. |
|---|---|---|---|---|
| | | *m. p. s.* | | *m.* |
| Camp Alfred Vail, N. J | 16 | 47 | wsw. | 500 |
| Camp Benning, Ga | 7 | 43 | w. | 5,000 |
| Do | 9 | 41 | wnw. | 6,800 |
| Do | 14 | 46 | w. | 7,300 |
| Bolling Field, D. C | 10 | 41 | sw. | 1,400 |
| Fort Bragg, N. C | 7 | 50 | w. | 3,500 |
| Broken Arrow, Okla | 7 | 61 | w. | 6,500 |
| Fort Curtis, Va | 14 | 42 | nw. | 3,200 |
| Drexel, Nebr | 5 | 40 | wsw. | 4,400 |
| Ellendale, N. Dak | 27 | 54 | wnw. | 4,000 |
| Groesbeck, Tex | 13 | 46 | w. | 4,400 |
| Do | 24 | 46 | wsw. | 9,500 |
| Kelly Field, Tex | 11 | 40 | w. | 1,400 |
| Lansing, Mich | 27 | 42 | wnw. | 2,250 |
| Camp Lewis, Wash | 19 | 60 | wsw. | 2,000 |
| Fort Riley, Kan | 26 | 45 | w. | 6,700 |

In order to verify the high velocities recorded at Ellendale on the 27th and at Groesbeck on the 13th, a second observation was made immediately after the first at both of these stations and the results found were substantially the same, thereby adding to the confidence which may generally be placed in single theodolite observations even in high winds.

The observation at Camp Alfred Vail on the 16th is cited because of the abnormally rapid increase in the wind speed at a comparatively short distance above the surface. The recorded velocities indicated a surface wind of but 9 meters per second overrun by a gale of 47

[1] *Meteorological Magazine*, April 1923, pp. 68-69.

[1] *Meteorological Magazine*, April 1923, pp. 68-69.

meters per second just 500 meters above. A strong substantiation of this rather unusual condition was found in the observations at several near-by stations although the extreme velocity and the rate of increase with altitude were somewhat less than at Camp Vail. A similar occurrence was found at Kelly Field, Tex., on the 11th when the velocity increased from 13 meters per second at the ground to 40 at 600 meters above. Pressure conditions in the two cases were quite similar. Camp Vail was at the time in the southeast quadrant of a strong barometric depression which subsequently moved very rapidly northeastward; Kelly Field was in the southwestern quadrant of a LOW which later moved rapidly northeastward and increased greatly in intensity.

The hurricane velocity of 60 meters per second (133 m. p. h.) observed at Camp Lewis, Wash., on the 19th at 2,000 meters elevation was an accompaniment of a disturbance of wide extent moving in over the Canadian Northwest following the intense cold wave over the country at this time.

Winds of 40 meters per second or more reported on the 7th over Oklahoma, Georgia, and North Carolina at elevations above 4,000 meters appear significant in view of the rapid east-northeastward movement of the severe cyclonic depression central on that morning south of the southern New England coast. In this same connection the great velocities recorded at Groesbeck on the 24th may be mentioned and seem very likely to be directly associated with the unexpectedly rapid movement of the pressure areas over the western and central sections of the country at and immediately following this time.

Both a. m. and p. m. pilot balloon observations at Groesbeck on the 8th showed a backing of the wind with increase in altitude as follows: South at surface, east at 2,000 meters, north at 2,500 meters, and west above 3,000 meters. This turning is more characteristic of the summer season than of spring since the percentage of counterclockwise turning with altitude for south surface winds at this station is normally less than 5 per cent for spring whereas for summer it is 25 per cent.

A diurnal series consisting of 9 kite flights was obtained at Groesbeck, extending from 7:25 a. m. of the 17th to 9:50 a. m. of the 18th, during which time a severe cold wave arrived over this region. The average maximum altitude reached for the series was 3,165 meters, the highest flight being 3,939 meters at 8:58 a. m. on the 17th and the lowest 2,707 meters at 4:54 a. m. on the 18th. The wind at the surface remained southerly during the first 7 flights of the series, veering with increase in altitude to WSW. above 2,000 meters elevation. The first evidence of a northerly component appeared at the surface at 4:15 a. m. of the 18th. This had reached the 1,000 meter level by 6 a. m. but had not extended above 1,300 meters by 9:21 a. m. when the series was ended. The pilot-balloon observation taken at 2 p. m. indicated surface north-northwesterly winds backing to WNW. at 1,500 meters, when the balloon was lost in stratus clouds. The presence of 10/10 stratus clouds at this time and the fact that they were moving from the WSW. seems to indicate that the wedge of northerly air did not extend above 1,500 meters altitude at this place. This fact is further borne out by the 7 p. m. cloud observation at Palestine, Tex., which was 10/10 strato-cumulus from the south, there being no 7 p. m. observation available from Groesbeck. The temperature distribution shows an abundance of interesting characteristics, one of the more striking of which was the gradual elevation of an inversion layer extending first from 1,000 meters to 1,400 meters until it was found during the last flight to lie between 1,800 meters and 2,200 meters. Its average lapse rate was roughly −2° per 100 meters. During the eighth flight a second inversion made its appearance, extending from the surface to 700 meters above, and the ninth and last flight showed this to have risen so that it reached from 700 to 1,200 meters with an average lapse rate of −2° per 100 meters.

TABLE 1.—*Free-air temperatures, relative humidities and vapor pressures during March, 1923.*

| Altitude. m. s. l. *m.* | Broken Arrow, Okla. (233 *m.*) Mean. | Departure from 5-year mean. | Drexel, Nebr. (396 *m.*) Mean. | Departure from 8-year mean. | Due West, S. C. (217 *m.*) Mean. | Departure from 3-year mean. | Ellendale, N. Dak. (444 *m.*) Mean. | Departure from 6-year mean. | Groesbeck, Tex. (141 *m.*) Mean. | Departure from 5-year mean. | Royal Center, Ind. (225 *m.*) Mean. | Departure from 5-year mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TEMPERATURE (°C.).** | | | | | | | | | | | | |
| Surface | 8.8 | −1.9 | −1.8 | −5.3 | 12.7 | −1.9 | −6.7 | −3.7 | 11.9 | −1.8 | 6.8 | −4.2 |
| 250 | 8.7 | −1.9 | ...... | ...... | 12.5 | −1.8 | ...... | ...... | 11.2 | −1.9 | 0.6 | −4.2 |
| 500 | 6.6 | −2.1 | −2.2 | −5.1 | 11.0 | −1.1 | −7.0 | −3.9 | 10.0 | −1.8 | −1.4 | −4.3 |
| 750 | 4.9 | −2.5 | −2.8 | −4.7 | 9.6 | −1.0 | −8.0 | −4.5 | 9.2 | −1.6 | −2.5 | −4.4 |
| 1,000 | 4.0 | −2.6 | −3.1 | −4.6 | 8.5 | −1.0 | −8.7 | −5.2 | 9.0 | −1.0 | −3.1 | −4.3 |
| 1,250 | 3.4 | −2.6 | −2.9 | −4.4 | 7.2 | −1.1 | −9.2 | −5.4 | 8.2 | −1.1 | −4.0 | −4.6 |
| 1,500 | 2.6 | −2.7 | −3.2 | −4.4 | 5.9 | −1.2 | −9.4 | −5.2 | 7.7 | −1.0 | −4.7 | −4.6 |
| 2,000 | 1.0 | −2.6 | −4.7 | −4.1 | 3.7 | −1.0 | −10.0 | −4.4 | 6.8 | −0.6 | −5.9 | −4.3 |
| 2,500 | −1.4 | −2.6 | −7.0 | −3.9 | 1.9 | −0.9 | −12.4 | −4.6 | 5.8 | +0.5 | −8.0 | −4.2 |
| 3,000 | −3.8 | −2.5 | −9.1 | −3.4 | 0.0 | −0.9 | −14.9 | −4.6 | 4.4 | +1.4 | −10.4 | −4.3 |
| 3,500 | −6.0 | −2.3 | −11.8 | −3.4 | −2.1 | −0.8 | −17.2 | −4.5 | 1.8 | +1.7 | −10.0 | −1.8 |
| 4,000 | −8.0 | −1.5 | −14.1 | −3.1 | −4.5 | −1.6 | −20.2 | −4.9 | −1.1 | +1.7 | ...... | ...... |
| 4,500 | −10.8 | −0.9 | −17.3 | −2.7 | −7.7 | −1.6 | −23.8 | −5.1 | −4.4 | +1.0 | ...... | ...... |
| 5,000 | ...... | ...... | ...... | ...... | ...... | ...... | −27.5 | −5.5 | −7.7 | +0.3 | ...... | ...... |
| **RELATIVE HUMIDITY (%).** | | | | | | | | | | | | |
| Surface | 59 | −6 | 74 | +6 | 63 | −1 | 76 | 00 | 66 | −4 | 68 | −2 |
| 250 | 59 | −6 | ...... | ...... | 63 | −1 | ...... | ...... | 66 | −3 | 68 | −2 |
| 500 | 59 | −5 | 72 | +5 | 61 | −3 | 75 | +1 | 64 | −2 | 65 | −3 |
| 750 | 58 | −5 | 68 | +3 | 59 | −5 | 70 | +3 | 64 | 0 | 60 | −5 |
| 1,000 | 56 | −5 | 62 | +1 | 58 | −7 | 67 | +5 | 60 | −1 | 56 | −6 |
| 1,250 | 51 | −6 | 58 | +3 | 57 | −8 | 65 | +7 | 59 | +2 | 52 | −7 |
| 1,500 | 47 | −6 | 56 | +5 | 57 | −8 | 63 | +7 | 58 | +6 | 47 | −10 |
| 2,000 | 40 | −5 | 59 | +10 | 50 | −9 | 58 | +4 | 49 | +8 | 40 | −14 |
| 2,500 | 39 | −4 | 63 | +14 | 46 | −4 | 57 | +3 | 43 | +7 | 38 | −15 |
| 3,000 | 46 | +5 | 60 | +10 | 43 | 00 | 55 | +2 | 42 | +10 | 42 | −12 |
| 3,500 | 54 | +11 | 59 | +10 | 39 | +2 | 52 | −1 | 43 | +11 | ...... | ...... |
| 4,000 | 50 | +10 | 55 | +7 | 38 | +2 | 46 | −7 | 44 | +11 | ...... | ...... |
| 4,500 | 49 | +10 | 53 | −1 | 36 | +2 | 50 | −5 | 44 | +9 | ...... | ...... |
| 5,000 | ...... | ...... | ...... | ...... | ...... | ...... | 52 | −5 | 44 | +11 | ...... | ...... |
| **VAPOR PRESSURE (*mb.*).** | | | | | | | | | | | | |
| Surface | 6.79 | −2.11 | 3.96 | −1.39 | 9.83 | −1.44 | 2.91 | −1.02 | 10.16 | −1.64 | 4.57 | −2.02 |
| 250 | 6.72 | −2.10 | ...... | ...... | 9.68 | −1.42 | ...... | ...... | 9.79 | −1.49 | 4.48 | −1.98 |
| 500 | 5.82 | −1.99 | 3.71 | −1.34 | 8.59 | −1.30 | 2.81 | −1.00 | 8.91 | −1.13 | 3.67 | −1.84 |
| 750 | 5.11 | −1.89 | 3.29 | −1.23 | 7.67 | −1.37 | 2.43 | −0.88 | 8.51 | −0.64 | 3.11 | −1.81 |
| 1,000 | 4.63 | −1.77 | 2.91 | −1.14 | 7.06 | −1.39 | 2.13 | −0.90 | 7.94 | −0.28 | 2.71 | −1.71 |
| 1,250 | 4.10 | −1.70 | 2.74 | −0.90 | 6.43 | −1.45 | 1.96 | −0.87 | 7.40 | +0.12 | 2.37 | −1.65 |
| 1,500 | 3.58 | −1.55 | 2.57 | −0.72 | 5.70 | −1.40 | 1.88 | −0.77 | 7.02 | +0.67 | 2.07 | −1.64 |
| 2,000 | 2.68 | −1.26 | 2.29 | −0.49 | 4.10 | −1.35 | 1.63 | −0.64 | 5.46 | +1.06 | 1.69 | −1.44 |
| 2,500 | 2.22 | −1.02 | 2.05 | −0.32 | 3.04 | −0.89 | 1.28 | −0.62 | 4.64 | +1.37 | 1.50 | −1.20 |
| 3,000 | 2.11 | −0.54 | 1.67 | −0.34 | 2.25 | −0.49 | 0.94 | −0.56 | 4.28 | +1.70 | 1.28 | −1.14 |
| 3,500 | 2.00 | −0.40 | 1.34 | −0.31 | 1.43 | −0.43 | 0.68 | −0.53 | 3.90 | +1.63 | ...... | ...... |
| 4,000 | 1.73 | −0.34 | 1.02 | −0.40 | 0.77 | −0.53 | 0.45 | −0.51 | 3.38 | +1.30 | ...... | ...... |
| 4,500 | 1.56 | −0.29 | 0.88 | −0.41 | 0.07 | −0.53 | 0.37 | −0.38 | 3.23 | +1.24 | ...... | ...... |
| 5,000 | ...... | ...... | ...... | ...... | ...... | ...... | 0.27 | −0.31 | 3.11 | +1.29 | ...... | ...... |

TABLE 2.—*Free-air resultant winds, m. p. s., during March, 1923.*

| Altitude. m. s. l. (m.) | Broken Arrow, Okla. (233m.) | | | | Drexel, Nebr. (396m.) | | | | Due West, S. C. (217m.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | | 5-year mean. | | Mean. | | 8-year mean. | | Mean. | | 3-year mean. | |
| | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. |
| Surface | S. 36°W. | 2.0 | S. 4°W. | 2.9 | N. 73°W. | 0.6 | S. 43°W. | 0.8 | S. 42°W. | 1.7 | S. 49°W. | 2.0 |
| 250 | S. 35°W. | 2.0 | S. 4°W. | 3.1 | ........ | .... | ........ | .... | S. 47°W. | 2.5 | S. 50°W. | 2.2 |
| 500 | S. 28°W. | 2.7 | S. 8°W. | 4.7 | N. 82°W. | 1.4 | S. 46°W. | 1.1 | S. 55°W. | 3.4 | S. 53°W. | 3.1 |
| 750 | S. 28°W. | 3.2 | S. 11°W. | 5.9 | N. 70°W. | 3.7 | S. 72°W. | 2.3 | S. 68°W. | 4.3 | S. 58°W. | 4.2 |
| 1,000 | S. 35°W. | 4.5 | S. 23°W. | 6.8 | N. 63°W. | 5.2 | S. 83°W. | 3.1 | S. 71°W. | 6.2 | S. 60°W. | 5.5 |
| 1,250 | S. 40°W. | 5.1 | S. 32°W. | 7.5 | N. 62°W. | 6.7 | N. 87°W. | 4.1 | S. 69°W. | 7.7 | S. 60°W. | 7.2 |
| 1,500 | S. 47°W. | 6.0 | S. 48°W. | 6.9 | N. 62°W. | 7.1 | N. 88°W. | 5.2 | S. 70°W. | 10.4 | S. 66°W. | 9.1 |
| 2,000 | S. 63°W. | 8.5 | S. 62°W. | 7.4 | N. 67°W. | 9.8 | N. 83°W. | 6.9 | S. 76°W. | 13.7 | S. 71°W. | 11.7 |
| 2,500 | N. 82°W. | 7.2 | S. 74°W. | 7.6 | N. 74°W. | 12.8 | W. | 8.8 | S. 81°W. | 14.5 | S. 81°W. | 13.2 |
| 3,000 | S. 86°W. | 9.3 | S. 81°W. | 8.8 | N. 77°W. | 16.2 | W. | 11.4 | S. 76°W. | 15.9 | S. 81°W. | 13.5 |
| 3,500 | S. 89°W. | 8.6 | S. 74°W. | 10.3 | N. 76°W. | 17.8 | N. 84°W. | 14.8 | S. 78°W. | 18.6 | S. 80°W. | 13.3 |
| 4,000 | S. 85°W. | 8.4 | S. 81°W. | 10.4 | N. 71°W. | 21.9 | N. 76°W. | 17.8 | N. 86°W. | 17.9 | S. 84°W. | 14.5 |
| 4,500 | N. 68°W. | 11.6 | S. 83°W. | 10.9 | N. 77°W. | 19.3 | N. 81°W. | 17.5 | N. 68°W. | 18.8 | N. 89°W. | 12.6 |
| 5,000 | N. 68°W. | 11.0 | S. 83°W. | 11.3 | W. | 18.1 | N. 80°W. | 15.7 | ........ | .... | ........ | .... |

| Altitude. m. s. l. (m.) | Ellendale, N. Dak. (444m.) | | | | Groesbeck, Tex. (141m.) | | | | Royal Center, Ind. (225m.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | | 6-year mean. | | Mean. | | 5-year mean. | | Mean. | | 5-year mean. | |
| | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. |
| Surface | N. 45°W. | 4.5 | N. 47°W. | 2.0 | S. 35°E. | 1.0 | S. | 1.5 | S. 57°W. | 3.2 | S. 33°W. | 2.1 |
| 250 | ........ | .... | ........ | .... | S. 30°E. | 1.3 | S. 2°E. | 2.2 | S. 56°W. | 3.4 | S. 32°W. | 2.4 |
| 500 | N. 49°W. | 4.6 | N. 55°W. | 1.8 | S. 3°E. | 1.9 | S. 9°W. | 4.0 | S. 56°W. | 6.5 | S. 42°W. | 5.1 |
| 750 | N. 62°W. | 4.9 | N. 84°W. | 2.4 | S. 11°W. | 3.2 | S. 21°W. | 4.9 | S. 70°W. | 8.9 | S. 49°W. | 6.5 |
| 1,000 | N. 70°W. | 5.7 | S. 89°W. | 3.1 | S. 31°W. | 3.6 | S. 33°W. | 5.6 | S. 75°W. | 11.4 | S. 59°W. | 7.4 |
| 1,250 | N. 68°W. | 6.9 | N. 85°W. | 4.1 | S. 37°W. | 3.9 | S. 40°W. | 5.9 | S. 80°W. | 12.5 | S. 65°W. | 8.4 |
| 1,500 | N. 66°W. | 8.3 | N. 84°W. | 5.5 | S. 31°W. | 3.4 | S. 44°W. | 5.8 | N. 88°W. | 13.5 | S. 69°W. | 9.1 |
| 2,000 | N. 64°W. | 10.7 | N. 82°W. | 7.9 | S. 47°W. | 3.7 | S. 58°W. | 6.8 | N. 81°W. | 14.7 | S. 75°W. | 10.7 |
| 2,500 | N. 67°W. | 13.9 | N. 78°W. | 10.7 | S. 68°W. | 5.9 | S. 64°W. | 8.7 | S. 87°W. | 17.0 | S. 79°W. | 11.7 |
| 3,000 | N. 77°W. | 16.5 | N. 79°W. | 11.9 | S. 73°W. | 7.8 | S. 68°W. | 9.0 | N. 76°W. | 21.2 | S. 86°W. | 14.0 |
| 3,500 | N. 76°W. | 17.3 | N. 83°W. | 13.7 | S. 54°W. | 14.5 | S. 72°W. | 12.0 | N. 79°W. | 28.6 | S. 82°W. | 16.5 |
| 4,000 | N. 87°W. | 14.1 | S. 89°W. | 15.0 | S. 60°W. | 14.8 | S. 67°W. | 13.7 | ........ | .... | ........ | .... |
| 4,500 | S. 85°W. | 17.3 | S. 86°W. | 16.3 | S. 68°W. | 15.3 | S. 83°W. | 13.3 | ........ | .... | ........ | .... |
| 5,000 | W. | 19.6 | N. 88°W. | 17.8 | S. 68°W. | 15.3 | S. 81°W. | 15.9 | ........ | .... | ........ | .... |

## THE WEATHER ELEMENTS.

By P. C. DAY, Meteorologist in Charge of Division.

### PRESSURE AND WINDS.

The rapid changes in the atmospheric circulation during the several months of the past winter, referred to previously, which showed some signs of abating in February, were renewed during March, and the month as a whole more than maintained its reputation for unpleasant weather, and, in some portions at least, ran true to tradition concerning lamb-like entrance and lion-like exit.

The pressure for the month as compared with the normal was, as during the preceding month, high over nearly all districts of the United States and Canada, the only exceptions being the Great Lakes and St. Lawrence Valley regions, where, unlike February, the averages were slightly less than normal. Pressure was distinctly above normal over the far Northwest, due to the presence of a well-developed anticyclonic condition that persisted during much of the month over that region.

The pressure for March, 1923, as compared with the preceding month, showed diminution in all parts of the country, as might be expected, though the changes were unusually large over all districts and particularly in the central and northwestern districts, due mainly to the abnormally high pressure of February.

Among the more important anticyclones of the month were the following:

On the morning of the 17th high pressure appeared in the far Canadian Northwest, attended by a sharp fall in temperature, which during the following two days overspread the Great Plains, central valleys and West Gulf States, bringing below-zero temperatures into the upper Mississippi Valley and adjacent regions, and freezing weather almost to the lower Rio Grande Valley. During the following 24 hours it moved rapidly to the South Atlantic coast, losing somewhat in severity of the attending cold, but still giving temperatures in numerous instances lower than ever before reported so late in the month. Again, on the morning of the 27th, high pressure moved into the Northwestern States and during the following 48 hours overspread the northern and central districts to the eastward of the Rocky Mountains, with attending low temperatures, again breaking the record for low temperatures so late in the season at a number of points in the central and northern districts. Before this anticyclone had passed off the Atlantic coast another had appeared in the British Northwest, and by the morning of the 30th had entered the United States with great strength between the Rocky Mountains and the Great Lakes, and penetrated into the central valleys during the last day of March and into the more eastern districts by the first of April. This, too, was attended by severe cold for the season, and many points in central and eastern districts again had the lowest temperatures ever observed so late in spring.

Cyclones were numerous, and frequently well-defined during the first half of the month, particularly over the Great Lakes and to the eastward. The outstanding storm of the month, however, moved from its position in central Texas on the morning of the 11th, to the southern end of Lake Michigan by the morning of the 12th, developing great force as it moved over the middle Mississippi Valley and adjacent territory. After leaving the Great Lakes, however, it lost energy rapidly, and was central over northern New England 24 hours later as a storm of only moderate intensity. This storm was attended by high winds, rain and snow over wide areas adjacent to its path, and local storms of great severity occurred, attended by loss of life and large damage to property, the details of which appear in other parts of this Review.

Aside from the storms of the 11th and 12th, other severe windstorms occurred locally during the first week of the month, and again on the 15th and 16th. The latter half of the month was comparatively free from storms of this character.

The usual notes concerning damaging storms appear in a table at the end of this section.

The frequent changes in pressure distribution during the month greatly complicated the wind systems, and the prevailing directions were not from common points over extensive areas, as shown on Chart VI.

### TEMPERATURE.

March was a month of frequent and sharp temperature changes, and on many occasions the weather bore the earmarks of winter more prominently than those of spring. This was particularly the case in portions of New England, where, on account of the long, cold winter, and the frequent lack of proper fuel or of even any at times, the hopes undoubtedly nurtured that March would bring relief were cruelly disappointing.

The first two weeks were moderately warm over the districts from the Rocky Mountains eastward, save during the second week when it was distinctly cold over the

Northeastern States, and mainly cool during both weeks from the Rocky Mountains westward.

The first few days of the month were especially warm over the upper Mississippi and lower Missouri Valleys and portions of the Middle Atlantic States, where the day temperatures were, in many cases, as high as or higher than ever before observed so early in the month. After the middle of the month, however, sharp changes to colder weather were frequent, and the week ending March 20th was unusually cold over the great central valleys and less so over nearly all other portions of the country, only small areas along the immediate Atlantic and Pacific coasts having temperatures above normal. Toward the end of the week a cold wave of unusual severity overspread practically all central and eastern districts and temperatures lower than ever before observed so late in March were reported from many sections.

The week following, ending March 27th, continued cold over practically all parts of the country, only small areas in the extreme East and far West having averages for the week above the normal. The week was particularly cold from the Dakotas eastward to the upper Lakes, where the averages were from 6° to 15° below normal. The final days of the month had two short periods of severe cold, confined principally to the central and eastern districts, where on both occasions temperatures lower than any previously recorded so late in spring were observed at numerous points. In the far West, however, there was a rapid warming up during the last few days of the month, and temperatures in portions of California and adjacent States were as high as ever observed in March.

For the month as a whole the average temperature was slightly above normal over the Atlantic coast States from southern Pennsylvania to Florida, over most of California and Oregon, and in portions of Washington, Idaho and Montana. Over all other portions of the United States, and generally over Canada, the monthly temperature averages were less than normal, and in the vicinity of the upper Lakes the month was among the coldest of record for March.

The principal warm periods were the first few days of the month in the Great Plains and Mississippi Valley, and to the eastward; on the 11th to 13th over most of the Gulf and South Atlantic States; on the 23d over the Northeastern States; and from the Rocky Mountains westward during the closing days of the month.

Important cold periods were from the 3d to 5th over the far western States; from the 8th to 9th in the Northeastern States; from the 18th to 20th over most districts from the Rocky Mountains eastward, and over much of the same area during the last few days of the month.

## PRECIPITATION.

Over much of the country from the Rocky Mountains eastward the precipitation for March, 1923, was in excess of the normal, and was generally well distributed through the month. However, an extensive area from Ohio and Kentucky northeastward to New England had somewhat less than usual, and in portions of the South Atlantic and Gulf States there were smaller areas with less than the normal amounts, particularly over the Florida Peninsula, and notably in the more southern portions. At Miami drought has continued since the first of the year, the total precipitation for the entire three months amounting to but slightly more than one inch, the least ever recorded at that station for a similar period.

West of the Rocky Mountains and in portions of the upper Missouri Valley and nearby territory, there was practically everywhere less than the normal precipitation, the deficiencies over California and the western districts of Oregon and Washington being particularly large.

In California the month was notably dry, San Francisco reporting the least rainfall in March for 74 years, the entire period of weather observations at that place. Likewise at Fresno, Sacramento and other points the outstanding feature of the weather was the almost entire absence of precipitation, a condition most unusual for that month. As February was also markedly dry it is becoming inevitable that there will be a serious shortage of water for irrigation and hydroelectric purposes during the coming summer. Similar conditions existed over much of Oregon and to a less extent in adjacent States.

The more important periods with extensive precipitation were as follows:

From the 3d to 5th when precipitation occurred very generally from the central Rocky Mountains eastward, the amounts being mostly light, except in portions of the middle and upper Mississippi and lower Missouri Valleys; on the 6th and 7th when general rains or snows prevailed from the Southern Plains northeastward and eastward, the falls being heavy in portions of the middle Mississippi and lower Ohio Valleys and Atlantic coast States; on the 11th to 13th from the eastern portions of the Great Plains to the Atlantic, the falls being heavy in portions of the Mississippi and lower Missouri Valleys, and locally in the Gulf and Atlantic coast States; from the 15th to 17th when precipitation was again general over the same region, the amounts being generous to heavy over much of the territory covered. More or less rain occurred over the Atlantic coast districts on the 19th and 20th, and again on the 22d and 23d. The latter part of the month was without extensive or heavy precipitation, save in Texas where heavy rains occurred at numerous central and eastern points on the 27th and 28th.

## SNOWFALL.

The snowfall was generally more than normal over the northern Plains and in northern districts to eastward. There was somewhat more than the average of March in districts to northward of a line joining Boston and Buffalo; and there was much more than normal to northward of a line from Detroit through Chicago to Kansas City. From central Iowa to east-central Michigan there was a notable fall on the 11th and 12th, the snow in much of the area being unusually wet, loading wires and trees till vast damage resulted, also hampering traffic greatly. Two additional heavy falls followed within a week's time, still further delaying traffic. The earlier of these two on the 14th–15th, was light east of Lake Michigan, but was remarkably heavy in eastern Nebraska and western Iowa; the later accompanied the marked fall in temperature on the 18th.

In northern Michigan, especially the eastern part of the upper peninsula, there were numerous snowstorms, but that of the last few days of the month, when high winds drifted the snow greatly, was especially troublesome. At Sault Ste Marie, as at several points in Wisconsin, Iowa and Missouri, the snowfall of the month was greater than that of any preceding month of record.

In northwestern Wisconsin and central Minnesota and thence westward to central Montana, the snowfall of the month was not particularly heavy, and in the southern and central Appalachian districts, also nearly everywhere south of central Ohio and central Illinois there was either no snowfall or comparatively little.

In the far West the snowfall of March was decidedly light in the California and Nevada mountains, and elsewhere was usually less than normal, save in Colorado, the northern Rockies and the Black Hills region. The end of the month found the snow stored for the water flow of spring and summer mainly less favorable than normal in the States that border Mexico and in the Pacific States. From Colorado to Montana the snow depths indicate a good supply, and in the middle and northern Plateau about an average supply.

In the northern portions of New England, New York, and Michigan the snow that still remained at the end of March was very deep, and some stations reported a greater depth of snow on the ground than at any previous time during their periods of record.

### RELATIVE HUMIDITY.

For the country as a whole the average relative humidity was less than normal. The dry conditions in the West were clearly indicated by the deficiency in the percentage of relative humidity, amounting in the drier localities to 25 per cent or more.

Over the central and eastern districts where precipitation was more nearly normal, or above, and of frequent occurrence, and where cool weather persisted, which would ordinarily indicate higher humidity conditions, the averages for the month were likewise less than normal in many sections. In the central and southern Rocky Mountain regions, and over the Great Lakes, portions of New England, and locally in the Southeastern States the relative humidity was above normal.

## SEVERE LOCAL STORMS, MARCH, 1923.

[The table herewith contains such data as have been received concerning severe local storms that occured during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

| Place. | Date. | Time. | Width of path. | Loss of life. | Value of property destroyed. | Character of storm. | Remarks. | Authority. |
|---|---|---|---|---|---|---|---|---|
| | | | *Yards.* | | | | | |
| St. Joseph, Mo., and vicinity | 3 | 5.40 p. m. | 50 | | $50,000 | Tornado | Many buildings damaged or blown down. Nine persons injured. | Official, U. S. Weather Bureau. |
| Western Wisconsin | 3-4 | | | | | Rain, sleet, and snow. | Miles of telephone, telegraph, and electric wires blown down. Railroad traffic paralyzed for a day. | Capital Times (Madison, Wis.); Sentinel (Milwaukee, Wis.). |
| Pittsburgh, Pa., and vicinity | 4 | P. m. | | 2 | | Wind | Many persons injured by flying glass; property damage heavy; barns destroyed; rail traffic delayed. | New York World (N. Y.); Baltimore Sun (Md.). |
| Palmyra, Mo. (near) | 5 | 9 p. m. | 100 | | 3,000 | Wind and rain | Houses and other buildings damaged | Official, U. S. Weather Bureau. |
| Central Alabama and Georgia. | 6 | P. m. | | | | do | Many buildings damaged; power lines, telephone and telegraph service crippled; two persons injured. Montgomery streets flooded. | Advertiser (Montgomery, Ala.). |
| Calhoun Falls, S. C. | 6 | P. m. | | | | Wind | Several houses unroofed | Official, U. S. Weather Bureau. |
| New York and adjacent States. | 6-7 | | | 3 | | Glaze and snow | Street-car service demoralized; trains delayed; wires down; harbor traffic almost tied up. Several persons injured. | Do. |
| Jackson, Mo | 11 | 7:45 p. m. | 225 | | 50,000 | Tornado | Track of damage one mile long; two persons injured. | Official, U. S. Weather Bureau. |
| Deanburg and Pinson, Tenn. | 11 | 8 p. m. | 300 | 20 | 100,000 | do | Seventy persons injured; 60 dwellings wrecked; freight train blown from track; wire communication cut off. | Official, U. S. Weather Bureau; News Scimitar (Memphis, Tenn.); Register (Springfield, Ill.). |
| Gallatin County, Ill | 11 | 9 p. m. | 300 | | 10,000 | do | Buildings and trees destroyed or damaged | Official, U. S. Weather Bureau. |
| Illinois (southern) | 11-12 | | | | | Wind | House blown off foundations; wire service crippled. | Do. |
| Indiana, especially southern | 11-12 | | | | 300,000 | do | Heavy property damage; public utilities companies suffer great loss; several persons injured. | Official, U. S. Weather Bureau; Evansville Journal (Ind.). |
| Kentucky (western and central). | 11-12 | | | 9 | 1,500,000 | do | Buildings blown down or damaged; much loss of live stock; wire lines crippled. | Official, U. S. Weather Bureau; Lexington Leader (Ky.). |
| Tennessee | 11-12 | | | | 600,000 | do | Buildings demolished or damaged; wire lines put out of business; some stock killed; trees uprooted or broken. | Official, U. S. Weather Bureau; Nashville Banner (Tenn.). |
| Arkansas, Mississippi, and northern Alabama. | 11-12 | | | 2 | | do | Buildings and wire lines blown down or injured; mules and horses killed; windows blown in. | Commercial Appeal (Memphis (Tenn.); Nashville Banner (Tenn.). |
| Wisconsin, eastern Iowa, and northern Illinois. | 11-12 | | | 3 | | Wind and snow | Wires broken down; trees destroyed; windows broken; rail and highway traffic greatly delayed. | Official, U. S. Weather Bureau; Wisconsin News (Milwaukee, Wis.); New York Times (N. Y.). |
| Western and southern Michigan. | 11-12 | | | | 2,000,000 | Wind and snow | Public utilities suffer heavy losses; other general damage done; serious delays of traffic. | Menominee Herald-Leader (Mich.). Free Press (Detroit, Mich.). |
| Ohio | 12 | | | 2 | | Wind | Six persons hurt; great property loss | Baltimore Sun (Md.). Tribune (New York, N. Y.). |
| Boydville, Ga. | 13 | | | 2 | | do | Several buildings blown down | Evansville Journal (Ind.). |
| Northwestern Mississippi | 15 | P. m. | | 16 | 350,000 | Tornado | Town of Savage completely wiped out; many persons injured and several hundred made homeless. | Commercial Appeal (Memphis, Tenn.). Indianapolis Star (Ind.). |
| Selmer, Tenn. (near) | 15 | | | | | Wind | Much timber blown down | Official, U. S. Weather Bureau. |
| Indianapolis, Ind | 15-16 | P. m. | | | 40,000 | do | Heavy damage to public utilities and to buildings. | Indianapolis News (Ind.). |
| Central and western New York. | 15-16 | | | 1 | | Wind and rain | Roofs, chimneys, and trees damaged considerably; property loss heavy; wire lines crippled. | Star (Oneonta, N. Y.). Press (Binghamton, N. Y.). |
| Yakima, Wash | 19 | | | | | Wind | Roofs, windows, and small buildings wrecked; some trees destroyed. | Official, U. S. Weather Bureau. |
| South Carolina (northwestern). | 23 | | | | 30,000 | Thunderstorms | Considerable damage, especially to buildings, by wind squalls. | Do. |

## STORMS AND WEATHER WARNINGS.

### WASHINGTON FORECAST DISTRICT.

*Storm warnings.*—Storm warnings were issued for portions of the Atlantic or the east Gulf coast on 13 days during the month, the most important being those of the 6th, 15th, 18-19th, and the 30th. In addition, small-craft warnings were issued on four days.

On the morning of the 6th an area of high pressure was over New England and a disturbance of considerable intensity was central over the lower Ohio Valley, moving northeastward with rapidly increasing intensity. At 9:30 a. m. northeast storm warnings were ordered for the Atlantic coast from the Virginia Capes northward and at 2 p. m. southwest warnings were displayed south of the Virginia Capes as far as Jacksonville, Fla. This storm became very severe by the time its center reached the southern New England coast and there were gales along the entire Atlantic seaboard from Jacksonville northward, several stations reporting velocities of 60 miles an hour or over, the highest, 68 miles an hour from the west, occurring at Cape Hatteras.

The next storm of marked intensity that reached the Atlantic coast was that of the 16th, warnings for which were displayed at 5 p. m. of the 15th. Southerly gales prevailed generally north of Cape Hatteras, and at both New York City and Sandy Hook, N. J., a maximum velocity of 76 miles an hour from the south occurred, which is especially high for southerly winds.

Again on the 19th there were west and northwest gales along the entire coast from Jacksonville, Fla., northward, in connection with a severe storm that was central over northern New York at 8 a. m. of that date and moving rapidly east-northeastward. The highest velocity reported was 72 miles an hour from the northwest at New York City, and many other stations experienced winds of 48 miles an hour or over. Warnings were issued well in advance for the entire area affected.

A slight disturbance which was over the eastern Gulf of Mexico on the morning of the 30th moved rapidly northeastward during the day with slowly increasing intensity and it was centered in the vicinity of Cape Hatteras at 8 p. m. During the night it became a storm of marked strength as it continued to move northeastward and it was quickly followed by a great area of high pressure and a cold wave from the Northwest. Northwest and north gales prevailed generally from Cape Hatteras northward, the highest velocity reported being 60 miles an hour from the north at Cape Henry.

*Cold-wave warnings.*—March was a month of frequent and marked temperature changes and cold-wave warnings were required on several dates after the middle of the month. On the morning of the 17th an area of high pressure with its crest over the upper Ohio Valley was moving east-northeastward. At the same time a disturbance of marked intensity was moving rapidly southeastward over the Rocky Mountain region and the Plain States, closely followed by an area of abnormally high pressure and a cold wave. The latter moved rapidly southeastward from Alaska over the Canadian Northwest. This type of pressure distribution was indicative of the steady advance of the northwestern area of high pressure and cold weather to the Atlantic and Gulf coasts, and, in the weekly forecast issued on Saturday the 17th, it was stated that decidedly colder weather would overspread the Eastern and Southern States Monday and Tuesday with frosts probable to the Gulf and south Atlantic coasts, except in Southern Florida. At the same time cold-wave warnings were issued for Ohio, western New York and western Pennsylvania, and at 8 p. m. for Kentucky, western Tennessee and northern New York. The following day they were extended to cover the balance of the Washington Forecast District, except southern and central Florida. The cold wave overspread the lower Lake Region and the Ohio and lower Mississippi valleys during Sunday night, and by Tuesday morning the warnings were fully verified at every station in the district, except in the Florida Peninsula.

Another cold wave advanced rapidly eastward over the upper Ohio Valley and the middle Atlantic and north Atlantic States during the 28th, and the lowest temperatures of record so late in the season were reported from stations in New York, Pennsylvania, Maryland, and the District of Columbia. The temperature fell somewhat lower than expected so that cold wave warnings were not issued, except for a very limited portion of this area.

The next cold wave quickly overspread middle and northern sections east of the Rocky Mountains, and there were record breaking temperatures on March 31st at 31 stations east of the Mississippi River and from Tennessee and North Carolina northward, and at 35 stations within the same area on Easter Sunday, April 1. Warnings of this cold wave were issued on the 30th for the greater portion of the region affected.

*Frost warnings.*—Frost warnings were issued for portions of the southeastern States on 11 dates during the month, the most important being those of the 18th and 19th. Freezing temperature occurred to the Alabama and extreme northwest Florida coast on the morning of the 20th, but cloudiness prevented the formation of frost, while killing frost was reported from the interior of the east Gulf States and at all stations in the south Atlantic States north of Florida.

*Heavy snow warnings.*—Warnings of heavy snow were issued for western Pennsylvania and western New York and for the Atlantic States north of Virginia on the 6th, and heavy snowfall was reported from much of this area.—*Charles L. Mitchell.*

### CHICAGO FORECAST DISTRICT.

The month of March was a most active one in the Chicago Forecast District. One disturbance after another moved across the district in rapid succession, usually taking the route across the southern portion, and followed by high-pressure areas and low temperature. As a consequence the total precipitation was rather heavy over the eastern portions of the district, and the temperature was generally below the seasonal normal, except in portions of Montana. The deficiencies were most marked in the upper Mississippi Valley and western Lake Region, where the departures ranged from 3° to more than 10°.

The first storm put in its appearance in the Canadian Northwest on the morning of the 1st, and moved directly southeastward over the Great Lakes, with a secondary storm reaching far to the rear over the middle Rockies. The former steadily lost energy while the latter became, by the 3d, the principal storm and crossed the Great Lakes on the 4th, attended by shifting gales and followed by much colder weather. No severe cold followed this storm, however, and cold-wave warnings were issued only for a limited area in the Northwest. Livestock warnings were issued on the 2d for North Dakota and Wyoming, and on the 3d for Nebraska and Kansas, as well as Wyoming; also on the night of the 3d advices

of dangerous gales on Lake Michigan were sent to ports maintaining winter navigation, vessel masters being warned not to leave port.

On the 4th additional disturbances appeared in Alberta and the southern Plateau region, the former moving southeastward and the latter northeastward, joining forces finally over the Ohio Valley, not however, causing any conditions in the Chicago Forecast District that justified special warnings, with the exception of cold-wave warnings in the northern Lake Region.

On the morning of the 10th low-pressure areas were centered in the Northwest and in the Southwest, which, by the morning of the 12th, had combined into a storm of remarkable energy, passing over Lake Michigan as a single storm accompanied by snow, sleet and rain, and heavy gales. The lowest barometer of record, 28.70 inches, was registered at Chicago at 2 a. m. of the 12th. Advisory messages were sent on the night of the 11th to all open ports on Lake Michigan of impending gales, and vessel masters were cautioned not to leave port. In addition advisory messages were sent on the morning of the 12th.

Before the last-named storm had disappeared down the St. Lawrence Valley, another, which appeared in British Columbia, was moving in a southeasterly direction across the Rockies. On the morning of the 13th the center had reached western Colorado and at the same time an area of high pressure (anticyclone) had advanced from the MacKenzie River basin to Alberta. This storm took a circuitous route, but finally reached the eastern limits of the Chicago Forecast District by the 15th and 16th, attended by widespread snow and rain and shifting gales, and followed by a sharp fall in temperature, reaching cold-wave proportions at several points. Livestock warnings were issued on the morning of the 14th for Nebraska, Kansas, and southern Wyoming; and advices of strong winds were sent to Lake Michigan ports on the night of that day. Advisory warnings for Lake Michigan were again sent on the morning of the 15th, and frost warnings were sent to the strawberry interests in southwestern Missouri.

On the morning of the 16th still another barometric depression had appeared in Alberta. This moved directly southward over the Rockies and was followed by an anticyclone of remarkable magnitude for the season of the year. The low (cyclone) finally recurved and passed eastward over the Chicago district on the 18th. Warnings of cold waves were sent on the evening of the 16th to the Dakotas, and northeastern Wyoming; and on the morning of the 17th the warnings were carried to the eastern limits of the forecast district, the cold wave to reach those points within 48 hours. Livestock warnings were also disseminated to points interested, and advices of gales generally throughout the district, including the open ports on Lake Michigan. The cold-wave warnings were justified at every station in the district, bringing to many points on the 17th and 18th record-breaking minima for the season after abnormally high maxima. The snow was heavy at several points in the middle West, and the storm, generally speaking, especially the cold-wave feature, was quite remarkable.

On the a. m. map of the 22d, a barometric depression of only moderate energy was centered in Alberta, and this was followed by an anticyclone that brought decided falls in temperature over the northern portion of this forecast district from North Dakota eastward. Warnings were issued to the area threatened.

On the p. m. map of the 23d a storm had reached British Columbia from Alaska, and this moved in a southeasterly direction over the Chicago Forecast District. The center on the morning of the 25th was in the middle Mississippi Valley with an anticyclone to the north with extremely low temperatures for the season. Cold-wave warnings were then issued for a considerable area in the Central States and these were verified; in fact, a few stations outside the area showed verifying falls in temperature.

Cold-wave warnings were again issued on the night of the 26th and the morning of the 27th, from Minnesota eastward over northern Wisconsin and lower Michigan, with ensuing temperature falls which reached the point of verification.

The month closed with another anticyclone of great magnitude moving southeastward over the forecast district from Alberta. On the morning of the 31st the lowest minima of record for the season of the year were registered at an unusually large number of stations in the middle West. It was, in fact, the coldest weather for the final day in March for more than a half century, and warnings of the cold were issued well in advance. The cold was not severe in the western portion of the forecast district, and warnings, therefore, were not necessary.

Because of the abnormal weather conditions prevailing during the month of March, the forecasts and warnings were doubtless of great service to transportation interests and shippers of perishable goods. Special forecasts were made for long periods, covering the considerable portion of a week whenever practicable, and this service invited much favorable comment. In the *Chicago Evening Post* of March 20, the following editorial appeared:

> With the tingle of yesterday's zero drop still sharp in memory, the moment is opportune to speak a kind word for the local weather bureau and Henry Cox, the efficient and accommodating forecaster. They may feel the need of kind words under what appears to be a conspiracy on the part of wind and temperature to make them unpopular.
>
> If you have been checking up on Mr. Cox and his assistants lately you will realize that they have a high batting average. It is pretty safe to bank on their predictions when you are figuring out what to wear, how to stoke the furnace, and the chances of getting home dry if you have left umbrella and rubbers behind. Up in the top of the Federal building it is something more than a guessing contest which is being operated by the vaticinatory gentlemen who consult barometers and compile bulletins from all parts of the continent. There is an uncanny accuracy about their ability to say in advance which way the wind will blow when it listeth, and just about where the mercury will stand in Mr. Fahrenheit's well-known column at a certain hour.
>
> And what we who work on a newspaper appreciate, and what our readers should appreciate, is the fact that Mr. Cox recognizes the high news value of the information he gathers and the deductions he makes, and takes care to see that no weather development of interest escapes our attention. His readiness to communicate all he learns and to answer questions no matter how often he may be bothered, constitute the weather bureau a public service bureau of great efficiency and value. An official who conducts his office with this idea of making it widely useful to the people deserves commendation.

—*H. J. Cox.*

### NEW ORLEANS FORECAST DISTRICT.

Unseasonably cold weather occurred in March on the West Gulf coast. Cold-wave warnings were issued at 2:20 p. m. on the 3d, for Oklahoma and northwestern Arkansas; were repeated at 8 p. m.; and were extended at 8 a. m. on the 4th, over Arkansas and northern Louisiana. The warnings were vertified over the greater portion of the area.

A moderate cold wave overspread the greater portion of the district, reaching the northern part on the night of the 15th, and the southern portion on the morning of the 17th, for which timely warnings were issued on the 15th.

An exceptionally serve cold wave for the season overspread the district during the 18th and 19th, for

which timely warnings were issued beginning for the northwestern portion of the district on the morning of the 17th; they were extended over the interior of the district at 8 p. m. of the 17th, and to the Gulf Coast on the morning of the 18th. The temperatures predicted for the different parts of the district occurred almost exactly as forecast.

Moderate cold waves occurred over the northern portion of the district on the 21st, 22d, and 29th, for which warnings were issued. No cold wave occurred without warning.

Moderate storm winds occurred on some portion of the West Gulf coast on the 6th, 12th, 15th, 16th, 18th, and 19th. Warnings were issued for some portion of the coast as follows: Small-craft warnings on the 3d, 11th, 15th, 17th, 18th, 20th, and 21st; storm warnings on the 6th, 11th, 14th, 15th, and 18th. Warnings were issued for all storm winds except at Galveston and Port Arthur on the 6th.

Fire-weather warnings were issued for Arkansas and Oklahoma on the 3d, and for Arkansas on the 14th and 18th.—*I. M. Cline.*

### DENVER FORECAST DISTRICT.

The month was cold and stormy, with an excess in precipitation in about all of the district, except the extreme southern portion.

On the morning of the 3d, when a disturbance of marked intensity was central over southeastern Colorado, warnings of heavy snow and much colder weather were issued to stockmen in eastern and southern Colorado and northwestern New Mexico. Light snow occurred throughout the region indicated, attended by a sharp fall in temperature that amounted almost to a cold wave.

Live-stock warnings were issued on the morning of the 9th to interests in southwestern Colorado, northwestern New Mexico, northeastern Arizona, and southern Utah, when heavy snow was expected to attend a LOW of considerable intensity that was central over southern Nevada. Moderately heavy snow occurred in southwestern Utah during the night of the 9th–10th, and light snow fell in the remainder of the region in which warnings were distributed.

A cold-wave warning was issued for north-central Arizona on the morning of the 10th. Although an area of decidedly low pressure which was central near Flagstaff moved rapidly eastward, a fall in temperature of only about 10 degrees occurred at that station.

Warnings of a moderate cold wave, issued on the 14th for southwestern Colorado, extreme northwestern New Mexico, northeastern Arizona, and extreme southeastern Utah, were justified, the temperature falling 16° to 20°, and to minima of 14° to 16°, over the area included in the warnings. Warning of a moderate cold wave for southern and extreme eastern New Mexico, issued on the evening of the 14th, was also justified, the fall in temperature east of the mountains in that State amounting to from 20° to 34°, with minimum temperatures at Santa Fe and Roswell of 8° and 22°, respectively, on the morning of the 16th.

Warnings of snow and a severe cold wave in eastern Colorado, and of snow and a moderate cold wave in northeastern New Mexico, including stockmen's warnings in eastern Colorado, were issued on the morning of the 17th, when a LOW of unusual intensity extended from the Southern Plateau States to the Upper Lakes, with its center over northeastern Colorado, while much higher pressures and severe cold weather prevailed over the sections to the northward. Cold-wave warnings, based upon 4 p. m. special observations, were extended to southeastern New Mexico on the afternoon of the 17th and were repeated on the evening of that date, when temperatures considerably below freezing were forecast for extreme southeastern New Mexico by the following morning. Moderately heavy snow fell in eastern Colorado during the afternoon and night of the 17th, with a severe cold wave overspreading northern and eastern Colorado by night and extending to extreme southeastern Mew Nexico by the morning of the 18th, when the temperature was below zero in northeastern Colorado and was but 16° above zero at Roswell, N. Mex. The fall in temperature in eastern Colorado amounted to from 34° to 40° during the 24 hours ending at 8 p, m. of the 17th, and at Roswell to 36° during the 24 hours ending at 8 p. m. of the 18th

On the evening of the 20th, when an area of low pressure extended from southern California northeastward to the Upper Lakes, with its center near Pueblo, where the barometer had fallen to 29.22 inches, warnings of a moderate cold wave were issued for eastern Colorado and southeastern and extreme northeastern New Mexico. The fall in temperature during the following 24 hours amounted to from 20° to 36° over the region specified, with the minimum temperature on the morning of the 22d ranging from 4° at Cheyenne to 26° at Roswell.

Warnings of a moderate cold wave were issued on the morning of the 21st for northern and eastern New Mexico, with live-stock warnings for the northeastern portion of that State, due to expected snow and strong northerly winds. The cold-wave warnings were fully justified, as already indicated, with strong winds and rain, turning to light snow, in northern New Mexico during the 21st and the night of the 22d.

A cold wave, without warning, occurred at Grand Junction, Colo., on the 18th, and at Durango, Colo., on the 22d.

Frost warnings were issued as follows: 4th, extreme southern New Mexico and southwestern Arizona; 5th and 6th, extreme southern New Mexico and southern Arizona; 10th, 11th, and 14th, south-central New Mexico and southern Arizona; 12th, south-central New Mexico and south-central and southeastern Arizona; 15th, 21st, and 22d, southern Arizona; 16th and 23d, southern New Mexico and south-central and southeastern Arizona; 18th, southern Arizona; 19th, south-central and southeastern Arizona; 25th, 27th, and 30th, southern New Mexico; 31st, extreme southeastern New Mexico. These warnings were generally verified.

The following freezing-temperature warnings were also issued: 16th, 23d, and 26th, extreme southeastern New Mexico; 18th, south-central and southwestern New Mexico; 19th and 22d, southern New Mexico. All of the foregoing warnings were verified at Roswell, El Paso, or the fruit-frost stations in southern New Mexico, except that of the 26th, the lowest temperatures on the morning of the 27th being 36°.—*J. M. Sherier.*

### SAN FRANCISCO FORECAST DISTRICT.

The dominant feature of March weather in this district was the persistence of a large and energetic area of high pressure off the northern coast. This condition deflected the storms from the north Pacific eastward at a high latitude, confined the areas of precipitation mostly to the western portions of Washington and Oregon, and caused a drought over the southern portion of the Pacific Slope.

On the 25th, the Pacific HIGH began to move inland and slowly developed a warm wave throughout this district from the 27th to the 29th, which broke records for high temperature in March at Sacramento and Portland and equaled the record at Roseburg.

On the 26th, radio reports from the *West Ivan* indicated the presence of a storm of considerable energy about 1,500 miles off the California-Oregon coast moving slowly eastward. On the morning of the 28th, Advisory messages were sent to all ports north of San Francisco, warning shipping bound for the Orient of the location and movement of the storm and that it would probably reach the northern coast about Friday evening (30th) and would later extend southward into California. This information was also given to the Associated Press, and was given marked prominence by the newspapers. The storm reached the northern coast Friday night and extended southward into California Saturday, breaking a drought which had prevailed for over a month. (See page 127.)

Storm warnings were ordered 15 times during the month as follows: On the California coast 8 times; on the Washington and Oregon coast 7 times. While some of these warnings were not verified by velocities reported at Weather Bureau stations, it is believed from radio reports received from vessels at sea, that they were all justified.—*G. H. Willson.*

## RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

Owing to the low temperatures and numerous heavy snows of the winter without any rains or thaws of consequence, the inhabitants of the North Atlantic States were apprehensive of severe floods at the end of the winter. Over much of New England more than 90 inches of snow had fallen during the winter and the thickness of the ice in the rivers ranged from a few up to 30 inches. It was obvious, therefore, that a few days of rain or of warm weather, or both, would result in disastrous floods. Fortunately the heavy snows came so early that the ground had not frozen, but on the other hand absorbed much of the snow and kept it from the streams, which were low. It was equally fortunate that no heavy rains or high temperatures occurred in March, so that, when the ice in the rivers broke up, it moved out without serious incident. The only flood stage reported in New England was in the Connecticut and White Rivers at White River Junction, Vt., where there was a crest stage on March 24 of 15 feet, or 2 feet above the flood stage. The damage done was small. At Hartford, Conn., on the Connecticut River, the ice moved out on March 23, navigation by the aid of tugs having been opened on March 21.

Flood stages were also reached about the same time in the Mohawk, the north branch of the Susquehanna and the upper Delaware rivers, but with little resulting damage. In the West Branch of the Susquehanna there was considerable disturbance following the melting of the snow from the high temperatures of March 2, 3 and 4. The ice went out at Renovo, Pa., on March 2, and at Harrisburg, Pa., on the main river, on March 4 and 5. Much damage was done along the West Branch, especially to railroads, both steam and electric, manufacturing plants, merchants, etc. The ice gorged below Lock Haven, Pa., on March 3, and on the following day many of the streets of the town were covered with water to a considerable depth, and railroad traffic was suspended. The loss and damage amounted to $60,000.

Warnings for all rivers were issued promptly as soon as the first indications of ice movement became apparent.

The heavy rains over the South Atlantic States about the middle of the month caused general floods that were well forecast. The floods, while more or less annoying, were not severe, and the total losses reported amounted to only $16,690, while property to the amount of $147,900 was reported to have been saved through the warnings issued by the Weather Bureau.

The Santee River of South Carolina remained in flood throughout the month.

The same general rains caused moderate floods in the Tombigbee, Pascagoula, and Pearl River systems of Alabama, Mississippi, and southern Louisiana, for which warnings were issued at the proper time. Apparently there was no damage of consequence.

The heavy rain area of the middle of the month extended northward over the Lake Erie and extreme southern Lake Huron basins, and in conjunction with moderately high temperatures caused some floods in the Maumee River of Indiana and Ohio and in the Flint and Pine Rivers of the Saginaw system of Michigan. Warnings were issued for the Maumee River and, while there was much inconvenience by seepage and sewer back-water, there was no damage of consequence. The Michigan floods were not of sufficient importance to require warnings.

Nothing of consequence occurred in the Ohio River or its tributaries east of Green River, Ky., but the main stream below Green River and all tributaries were in moderate flood for about ten days, beginning with March 13 in Green River and ending, as a rule, with March 28. All of the floods were forecast promptly and accurately. The damage was small, only $36,000 loss having been reported, while the estimated value of property saved through the warnings was $100,500. Also a considerable amount of property was saved, the actual values of which were not stated.

The Ohio River flood extended down the Mississippi River beginning with March 18 at New Madrid, Mo., and was in progress at the close of the month, but without promise of any unusual occurrences. All tributary streams from the Des Moines southward except the Missouri and Arkansas, were also in moderate flood, except in the Black and White Rivers of Arkansas, where the crest stages ranged from 2 to 9 feet above the flood stages. These floods were also well forecast and no damage was reported. In the Neosho and Arkansas Rivers of Oklahoma the rising waters caused damage to the amount of $24,000 to new bridge construction, although flood stages were not reached. Special warnings had previously been sent to the construction companies.

Local floods in the Sabine, Neches, Trinity and lower Guadalupe Rivers of Texas were of minor importance, and the total reported losses amounted to $10,000. The usual warnings were issued.

The ice gorges that formed in the Missouri River on March 22, at Sergeant Bluff, Iowa, and Decatur, Nebr., threatened for a time to produce disastrous results, but the absence of mild, rainy weather prevented a destructive overflow. The officials in charge of the Weather Bureau offices at Sioux City, Iowa, and Omaha, Nebr., moved with promptness, kept in intimate contact with the conditions, and through their timely and accurate warnings prevented the loss of a great quantity of movable prop-

erty, and probably of human lives also. As it was, two hunters who had ventured out, notwithstanding the threatening situation, were caught on a sandbar by the rapid rise of water near Mondamin, Iowa, about 60 miles below Sioux City, and lost their lives.

The dangerous conditions continued for several days, and it was not until the evening of March 25 that the official in charge at Sioux City felt justified in issuing a public statement that the crisis had passed. The backwater caused by the gorge at Sergeant Bluff caused a stage of 16.8 feet at Sioux City at 10 p. m., March 23, or 0.2 foot below the flood stage of 17 feet, which had been forecast, while the postmaster at Sergeant Bluff, who had rendered most valuable assistance in every way, stated that the water at that place was higher than it had been for at least 40 years.

*Flood stages during March, 1923.*

| River and station. | Flood stage. | Above flood stages—dates. | | Crest. | |
|---|---|---|---|---|---|
| | | From— | To— | Stage. | Date. |
| ATLANTIC DRAINAGE. | | | | | |
| *Connecticut:* | *Feet.* | | | *Feet.* | |
| White River Junction, Vt. | 13 | 24 | 26 | 15.0 | 24 |
| *Mohawk:* | | | | | |
| Tribeshill, N. Y | 16 | 17 | 20 | 20.4 | 17 |
| Do | 16 | 23 | 23 | 16.5 | 23 |
| Schenectady, N. Y | 15 | 24 | 24 | 17.6 | 24 |
| *Delaware:* | | | | | |
| Port Jervis, N. Y | 18 | 6 | 6 | 18.0 | 6 |
| *Susquehanna:* | | | | | |
| Bainbridge, N. Y | 11 | 18 | 20 | 13.2 | 18 |
| Do | 11 | 24 | 24 | 12.9 | 24 |
| *Susquehanna, W. Br.:* | | | | | |
| Williamsport, Pa | 20 | 5 | 5 | 21.4 | 5 |
| *James:* | | | | | |
| Columbia, Va | 18 | 17 | 17 | 23.0 | 17 |
| Richmond, Va | 10 | 18 | 18 | 12.1 | 18 |
| *Roanoke:* | | | | | |
| Randolph, Va | 21 | 17 | 19 | 28.0 | 18 |
| Weldon, N. C | 30 | 9 | 10 | 32.0 | 9 |
| Do | 30 | 18 | 23 | 45.0 | 20 |
| *Dan:* | | | | | |
| Danville, Va | 8 | 17 | 18 | 12.5 | 18 |
| Clarksville, Va | 12 | 19 | 19 | 14.2 | 19 |
| *Tar:* | | | | | |
| Rocky Mount, N. C | 9 | 17 | 17 | 9.4 | 17 |
| Tarboro, N. C | 18 | 19 | 24 | 21.6 | 21–22 |
| Greenville, N. C | 14 | 19 | 26 | 16.6 | 23 |
| *Neuse:* | | | | | |
| Neuse, N. C | 15 | 14 | 20 | 18.4 | 17 |
| Smithfield, N. C | 14 | 15 | 23 | 18.5 | 19 |
| *Cape Fear:* | | | | | |
| Fayetteville, N. C | 35 | 15 | 15 | 37.7 | 15 |
| Do | 35 | 18 | 20 | 40.0 | 18 |
| Elizabethtown, N. C | 22 | 1 | 3 | 24.3 | 2 |
| Do | 22 | 15 | 23 | 30.2 | 20 |
| *Peedee:* | | | | | |
| Cheraw, S. C | 27 | 14 | 21 | 35.3 | 19 |
| *Santee:* | | | | | |
| Rimini, S. C | 12 | ([1]) | ([2]) | 20.0 | 22 |
| Ferguson, S. C | 12 | 2 | ([2]) | 15.2 | 23 |
| *Catawba:* | | | | | |
| Catawba, S. C | 12 | 17 | 18 | 17.0 | 18 |
| *Wateree:* | | | | | |
| Camden, S. C | 24 | 15 | 16 | 26.6 | 15 |
| Do | 24 | 18 | 21 | 30.0 | 18 |
| *Congaree:* | | | | | |
| Columbia, S. C | 15 | 18 | 19 | 17.7 | 18–19 |
| *Broad:* | | | | | |
| Blairs, S. C | 15 | 14 | 14 | 16.8 | 14 |
| Do | 15 | 17 | 19 | 20.5 | 18 |
| *Saluda:* | | | | | |
| Pelzer, S. C | 7 | 17 | 19 | 8.0 | 18 |
| Chappels, S. C | 14 | ([1]) | 1 | 16.8 | 1 |
| Do | 14 | 14 | 15 | 15.7 | 14 |
| Do | 14 | 17 | 21 | 18.8 | 18 |
| *Broad:* | | | | | |
| Carlton, Ga | 11 | 13 | 13 | 14.0 | 13 |
| *Oconee:* | | | | | |
| Milledgeville, Ga | 22 | 17 | 17 | 23.3 | 17 |
| Do | 22 | 20 | 20 | 27.5 | 20 |
| *Ocmulgee:* | | | | | |
| Macon, Ga | 18 | 14 | 15 | 19.4 | 14 |
| Do | 18 | 19 | 20 | 19.2 | 20 |
| Abbeville, Ga | 11 | 7 | 7 | 11.1 | 7 |
| Do | 11 | 19 | 29 | 14.2 | 25 |
| Lumber City, Ga | 15 | 26 | 28 | 15.2 | 27 |

*Flood stages during March, 1923*—Continued.

| River and station. | Flood stage. | Above flood stages—dates. | | Crest. | |
|---|---|---|---|---|---|
| | | From— | To— | State. | Date. |
| EAST GULF DRAINAGE. | | | | | |
| *Apalachicola:* | *Feet.* | | | *Feet.* | |
| River Junction, Fla | 12 | 22 | ([2]) | 21.4 | 22 |
| Blountstown, Fla | 15 | 1 | 6 | 17.3 | 2 |
| Do | 15 | 15 | ([2]) | 21.0 | 22 |
| *Flint:* | | | | | |
| Albany, Ga | 20 | 23 | 26 | 22.8 | 25 |
| *Chattahoochee:* | | | | | |
| Columbus, Ga | 20 | 20 | 20 | 21.0 | 20 |
| Alaga, Ala | 30 | 20 | 22 | 34.2 | 20 |
| *Tombigbee:* | | | | | |
| Lock No. 4, Ala | 39 | 23 | ([2]) | 51.4 | 30 |
| *Black Warrior:* | | | | | |
| Lock No. 10, Ala | 46 | 24 | 25 | 50.0 | 24 |
| *Chickasawhay:* | | | | | |
| Enterprise, Miss | 21 | 23 | 26 | 26.4 | 26 |
| Shubuta, Miss | 27 | 25 | 30 | 33.2 | 27 |
| *Leaf:* | | | | | |
| Hattiesburg, Miss | 19 | 25 | 27 | 20.4 | 26 |
| *Pearl:* | | | | | |
| Edinburg, Miss | 21 | 25 | 28 | 22.6 | 26 |
| Jackson, Miss | 20 | 23 | ([2]) | 30.6 | 30 |
| Columbia, Miss | 18 | ([1]) | 4 | 20.4 | 1 |
| Do | 18 | 24 | ([2]) | 23.7 | 30 |
| *West Pearl:* | | | | | |
| Pearl River, La | 13 | ([1]) | 13 | 15.3 | 3–5 |
| Do | 13 | 26 | ([2]) | 15.7 | 29–31 |
| GREAT LAKES DRAINAGE. | | | | | |
| *Maumee:* | | | | | |
| Fort Wayne, Ind | 15 | 13 | 14 | 16.7 | 13 |
| Do | 15 | 16 | 19 | 19.3 | 17 |
| *St. Joseph:* | | | | | |
| Montpelier, Ohio | 10 | 4 | 4 | 10.8 | 4 |
| Do | 10 | 13 | 18 | 11.6 | 17 |
| *Auglaize:* | | | | | |
| Defiance, Ohio | 10 | 18 | 18 | 10.5 | 18 |
| *Flint:* | | | | | |
| Fosters, Mich | 18 | 5 | 5 | 18.0 | 5 |
| *Pine:* | | | | | |
| Alma, Mich | 6 | 4 | 8 | 7.2 | 6 |
| Do | 6 | 17 | 17 | 6.0 | 17 |
| Do | 6 | 23 | 26 | 6.3 | 23, 25 |
| *Red Cedar:* | | | | | |
| East Lansing, Mich | 8 | 5 | 5 | 8.2 | 5 |
| MISSISSIPPI DRAINAGE. | | | | | |
| *Ohio:* | | | | | |
| Evansville, Ind | 35 | 14 | 24 | 37.8 | 19–20 |
| Henderson, Ky | 33 | 15 | 24 | 35.7 | 20 |
| Dam No. 48, Ind | 35 | 17 | 23 | 36.9 | 20 |
| Mount Vernon, Ind | 35 | 17 | 26 | 37.4 | 21 |
| Shawneetown, Ill | 35 | 16 | ([2]) | 39.1 | 22 |
| Cairo, Ill | 45 | 18 | 28 | 46.7 | 21–22 |
| *Scioto:* | | | | | |
| La Rue, Ohio | 11 | 23 | 23 | 11.3 | 23 |
| *Green:* | | | | | |
| Lock No. 4, Ky | 33 | 8 | 11 | 35.8 | 10 |
| Do | 33 | 13 | 20 | 37.6 | 18–19 |
| Do | 33 | 25 | 26 | 33.6 | 25 |
| Lock No. 2, Ky | 34 | 13 | 31 | 38.5 | 22 |
| *Wabash:* | | | | | |
| La Fayette, Ind | 11 | 13 | 21 | 20.5 | 18 |
| Terre Haute, Ind | 16 | 17 | 24 | 19.7 | 20 |
| Vincennes, Ind | 14 | 18 | 28 | 18.7 | 24 |
| Mt. Carmel, Ill | 16 | 16 | 29 | 22.3 | 24–25 |
| *White:* | | | | | |
| Decker, Ind | 18 | 21 | 26 | 20.0 | 24 |
| *White, W. Fork:* | | | | | |
| Noblesville, Ind | 14 | 17 | 17 | 14.8 | 17 |
| Elliston, Ind | 19 | 16 | 21 | 24.7 | 19 |
| *Cumberland:* | | | | | |
| Nashville, Tenn | 40 | 12 | 17 | 41.7 | 13 |
| Clarksville, Tenn | 46 | 13 | 19 | 49.0 | 17 |
| Lock E, Canton, Ky | 50 | 15 | 21 | 52.8 | 19 |
| *Tennessee:* | | | | | |
| Knoxville, Tenn | 12 | 18 | 19 | 13.4 | 18 |
| Riverton, Ala | 33 | 23 | 26 | 36.5 | 25 |
| Johnsonville, Tenn | 31 | 25 | 26 | 31.2 | 26 |
| *French Broad:* | | | | | |
| Penrose, N. C | 13 | 17 | 17 | 13.4 | 17 |
| Asheville, N. C | 4 | 17 | 17 | 4.0 | 17 |
| *Big Pigeon:* | | | | | |
| Newport, Tenn | 6 | 7 | 7 | 6.3 | 7 |
| Do | 6 | 17 | 17 | 6.7 | 17 |
| *Mississippi:* | | | | | |
| New Madrid, Mo | 34 | 18 | ([2]) | 36.4 | 22–23 |
| Memphis, Tenn | 35 | 23 | ([2]) | 36.5 | 26 |
| Helena, Ark | 44 | 26 | ([2]) | 45.4 | 30–31 |
| Arkansas City, Ark | 48 | 30 | ([2]) | 48.6 | 31 |
| Vicksburg, Miss | 45 | 30 | ([2]) | 45.7 | 31 |
| *Des Moines:* | | | | | |
| Ottumwa, Iowa | 10 | 27 | 28 | 10.2 | 27–28 |

*Flood stages during March, 1923*—Continued.

| River and station. | Flood stage. | Above flood stages—dates. | | Crest. | |
|---|---|---|---|---|---|
| | | From— | To— | Stage. | Date. |
| MISSISSIPPI DRAINAGE—continued. | | | | | |
| *Illinois:* | *Feet.* | | | *Feet.* | |
| Peru, Ill. | 14 | 14 | (2) | 16.3 | 18 |
| Henry, Ill. | 7 | 15 | (2) | 10.4 | 25 |
| Peoria, Ill. | 16 | 19 | (2) | 17.2 | 28 |
| Havana, Ill. | 14 | 22 | (2) | 14.6 | 27-29 |
| Beardstown, Ill. | 12 | 16 | (2) | 15.4 | 28 |
| *Meramec:* | | | | | |
| Pacific, Mo. | 11 | 13 | 14 | 13.6 | 14 |
| Do. | 11 | 16 | 18 | 14.6 | 18 |
| Valley Park, Mo. | 14 | 14 | 14 | 15.4 | 14 |
| Do. | 14 | 16 | 19 | 16.9 | 18 |
| *Bourbeuse:* | | | | | |
| Union, Mo. | 10 | 14 | 14 | 10.0 | 14 |
| Do. | 10 | 17 | 18 | 11.7 | 18 |
| *St. Francis:* | | | | | |
| Marked Tree, Ark. | 17 | (1) | 7 | 18.0 | 1 |
| Do. | 17 | 19 | (2) | 18.7 | 30-31 |
| *Petit Jean:* | | | | | |
| Danville, Ark. | 20 | (1) | 1 | 20.5 | 1 |
| Do. | 20 | 7 | 9 | 21.5 | 8 |
| Do. | 20 | 17 | 19 | 22.7 | 18 |
| *White:* | | | | | |
| Calico Rock, Ark. | 18 | 16 | 16 | 18.8 | 16 |
| Batesville, Ark. | 23 | 16 | 17 | 25.6 | 17 |
| Newport, Ark. | 26 | 18 | 19 | 26.5 | 19 |
| Georgetown, Ark. | 22 | 17 | 29 | 23.4 | 22-23 |
| *Black:* | | | | | |
| Black Rock, Ark. | 14 | 12 | (2) | 23.6 | 18 |
| *Cache:* | | | | | |
| Patterson, Ark. | 9 | 11 | 29 | 9.6 | 16-17 |
| *Yazoo:* | | | | | |
| Yazoo City, Miss. | 25 | 2 | 14 | 26.2 | 7-8 |
| Do. | 25 | 16 | (2) | 27.2 | 27 |
| *Tallahatchie:* | | | | | |
| Swan Lake, Miss. | 25 | (1) | 8 | 26.9 | 1 |
| Do. | 25 | 28 | (2) | 26.7 | 31 |
| *Sulphur:* | | | | | |
| Ringo Crossing, Tex. | 20 | 7 | 9 | 20.5 | 7 |
| Finley, Tex. | 24 | 11 | 12 | 24.1 | 12 |
| *Ouachita:* | | | | | |
| Camden, Ark. | 30 | 2 | 5 | 31.9 | 4 |
| Do. | 30 | 9 | 14 | 34.0 | 11 |
| WEST GULF DRAINAGE. | | | | | |
| *Sabine:* | | | | | |
| Logansport, La. | 25 | (1) | 5 | 26.9 | 2 |
| Bon Weir, Tex. | 20 | 3 | 9 | 20.8 | 4-5 |
| Do. | 20 | 30 | (2) | 21.8 | 31 |
| *Neches:* | | | | | |
| Rockland, Tex. | 22 | 2 | 3 | 22.3 | 2 |
| *Trinity:* | | | | | |
| Liberty, Tex. | 25 | 3 | 4 | 25.6 | 3-4 |
| Do. | 25 | 31 | (2) | 25.5 | 31 |
| *Guadalupe:* | | | | | |
| Victoria, Tex. | 16 | 28 | 28 | 17.7 | 28 |
| Do. | 16 | 30 | (2) | 18.7 | 31 |

[1] Continued from February. [2] Continued into April.

## MEAN LAKE LEVELS DURING MARCH, 1923.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., April 7, 1923.]

The following data are reported in the "Notice to Mariners" of the above date:

| Data. | Lakes.[1] | | | |
|---|---|---|---|---|
| | Superior. | Michigan and Huron. | Erie. | Ontario. |
| Mean level during March, 1923: | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| Above mean sea level at New York | 601.45 | 578.98 | 570.98 | 244.74 |
| Above or below— | | | | |
| Mean stage of February, 1923 | −0.15 | +0.17 | +0.10 | +0.27 |
| Mean stage of March, 1922 | +0.22 | −0.44 | −0.41 | −0.34 |
| Average stage for March, last 10 years | −0.29 | −1.10 | −0.81 | −0.94 |
| Highest recorded March stage | −0.83 | −3.97 | −2.87 | −3.07 |
| Lowest recorded March stage | −0.79 | −0.13 | +0.15 | +0.44 |
| Average relation of the March level to— | | | | |
| February, level | | +0.10 | +0.10 | +0.20 |
| April, level | | −0.40 | −0.70 | −0.70 |

[1] Lake St. Clair's level: In March, 573.62 feet.

## EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, MARCH, 1923.

By J. B. KINCER, Meteorologist.

March, as a whole, was colder than normal in all sections of the country, except in the Middle and South Atlantic States, and in the far West and Northwest. The temperature averaged much below normal in the western Lake region, upper Mississippi Valley, and in the central and southern Rocky Mountain States. There was sufficient precipitation for agricultural needs, except in portions of Florida, parts of the Great Plains, some southwestern districts, and in California. Rainfall was heavy in most sections south of the Ohio and middle Mississippi Valleys, and snowfall was heavy in most northern localities from the upper Mississippi Valley eastward, with considerable cloudy weather in the South.

The first half of the month was comparatively mild east of the Rocky Mountains and vegetation and farm work made mostly satisfactory progress. The long drought in northwestern Texas, western Oklahoma, and eastern Kansas was broken by rather generous precipitation during the week ending March 13, but it continued dry in western Kansas, Nebraska, and the eastern portions of the central Rocky Mountain States.

Under the influence of mild temperatures in the Southern States, early fruit advanced rapidly and by the 20th of the month, early peaches, plums, and pears were blooming throughout the Gulf States and were coming into bloom northward to Oklahoma, northern Arkansas, and east-central North Carolina. At this time, a severe cold wave overspread all sections of the country east of the Rocky Mountains, the temperature dropping to 10° above zero in central Oklahoma, 14° above in central Arkansas, and 24° to 26° to the central portions of the east Gulf States. This freeze did much damage to early fruit throughout the Southern States, although the later varieties of peaches, including Elbertas in Georgia, were not badly damaged in some localities.

Winter wheat made but little growth during the last half of the month because of the prevailing cold weather and some damage was done by freezing in portions of the Ohio Valley. In the trans-Mississippi States the month was rather favorable for wheat, except in the drier sections of the Great Plains where the crop was in very poor condition. Oats suffered severe damage from the cold in the southern Great Plains, particularly in Oklahoma, and the latter part of the month was very unfavorable for the preparation of soil and seeding in the Central States. The weather was unfavorable also for the preparation of corn ground and planting was delayed in much of the South by the cool, wet weather.

Planting and replanting cotton made fair progress in southern Texas and at the close of the month, planting was more general in the Atlantic coast area, but considerable replanting was necessary in southern Georgia, where much early planted cotton was killed by the freeze of the 20th. The soil was too cold and wet for much field work in the central Gulf States.

There was sufficient precipitation to improve ranges in most of the great western grazing districts, although more moisture was badly needed in California and pastures were starting slowly in the North Pacific Coast States. The latter part of the month was cold, stormy, and unfavorable for stock in the central Rocky Mountain section, with some losses reported in Colorado. Grass was starting slowly in Central and Eastern States and much young clover was killed by freezing in the Ohio Valley section.

# CLIMATOLOGICAL TABLES.[1]

## CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

*Condensed climatological summary of temperature and precipitation by sections, March, 1923.*

| Section. | Temperature. | | | | | | | | Precipitation. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Section average. | Departure from the normal. | Monthly extremes. | | | | | | Section average. | Departure from the normal. | Greatest monthly. | | Least monthly. | |
| | | | Station. | Highest. | Date. | Station. | Lowest. | Date. | | | Station. | Amount. | Station. | Amount. |
| | °F. | °F. | | °F. | | | °F. | | In. | In. | | In. | | In. |
| Alabama | 55.0 | −1.4 | Auburn | 89 | 13 | 2 stations | 16 | 20 | 6.36 | +0.74 | Union Springs | 10.35 | Uniontown | 3.27 |
| Arizona | 49.5 | −2.9 | Mohawk | 93 | 31 | Springer Valley Ranger Station. | 0 | 5 | 1.01 | −0.17 | Ashdale Ranger Station. | 5.10 | 2 stations | 0.00 |
| Arkansas | 49.6 | −3.0 | Portland | 88 | 22 | Nail | 2 | 18 | 5.04 | +0.34 | Patterson | 10.55 | Fort Smith | 2.12 |
| California | 52.8 | +1.0 | Oroville (near) | 94 | [2] 27 | Tamarack | −10 | 4 | 0.43 | −3.57 | Nellie | 5.72 | 17 stations | 0.00 |
| Colorado | 29.4 | −4.9 | Canon City | 79 | 2 | 2 stations | −25 | 18 | 1.65 | +0.40 | Silver Lake | 7.10 | Saguache | T. |
| Florida | 67.7 | +2.0 | Lake Wales | 94 | 17 | 2 stations | 26 | 20 | 2.08 | −0.87 | Cottage Hill | 7.98 | Punta Gorda | 0.21 |
| Georgia | 57.3 | +0.5 | 2 stations | 88 | [2] 12 | Blue Ridge | 12 | 20 | 6.00 | +1.11 | Concord | 9.59 | Waycross | 2.28 |
| Idaho | 32.9 | −2.7 | Bliss | 85 | 31 | Felt | −22 | 5 | 0.86 | −0.74 | Wallace | 3.29 | Glenns Ferry | 0.00 |
| Illinois | 37.2 | −3.0 | Mascoutah | 79 | 2 | Aledo | −12 | 19 | 4.34 | +1.32 | Pontiac | 6.08 | Waukegan | 1.77 |
| Indiana | 38.7 | −1.7 | Vevay | 78 | 12 | 3 stations | 0 | 19 | 3.81 | +0.08 | Vincennes | 5.74 | Whiting | 1.07 |
| Iowa | 29.4 | −3.9 | Thurman | 78 | 1 | Boone | −22 | 19 | 2.87 | +1.10 | Sigourney | 5.08 | West Bend | 0.71 |
| Kansas | 40.8 | −3.0 | Medicine Lodge | 83 | 2 | 4 stations | −8 | 19 | 1.54 | −0.11 | Walnut | 5.48 | Ulysses | 0.02 |
| Kentucky | 45.6 | −0.4 | Williamsburg | 80 | 3 | Blandville | 8 | 19 | 5.27 | +0.61 | Hopkinsville | 8.02 | Marion | 2.70 |
| Louisiana | 58.6 | −2.4 | Stables | 89 | 4 | Kelly | 16 | 20 | 6.34 | +1.83 | Alexandria | 11.89 | Morgan City | 3.48 |
| Maryland-Delaware | 43.4 | +1.4 | Frederick, Md | 82 | 23 | Oakland, Md | −6 | 9 | 4.40 | +0.75 | Crisfield, Md | 7.28 | Cumberland, Md | 1.69 |
| Michigan | 23.6 | −5.6 | 2 stations | 62 | [2] 2 | Ewen | −38 | 19 | 2.98 | +0.94 | Manistee | 5.90 | Mancelona | 1.20 |
| Minnesota | 17.9 | −8.2 | 3 stations | 66 | [2] 1 | Meadowlands | −40 | 19 | 0.77 | −0.45 | Chatfield | 2.72 | 2 stations | 0.05 |
| Mississippi | 54.8 | −2.5 | 2 stations | 87 | 12 | 2 stations | 15 | 19 | 7.44 | +1.73 | Fayette | 15.72 | Bay St. Louis | 3.67 |
| Missouri | 40.4 | −3.1 | Conception (2) | 83 | 2 | Grant City | −11 | 19 | 4.12 | +1.00 | Poplar Bluff | 8.30 | Edgerton | 1.57 |
| Montana | 30.4 | +0.3 | Libby | 73 | 30 | Hebgen Dam | −32 | 4 | 0.64 | −0.25 | Heron | 3.12 | Three Forks | T. |
| Nebraska | 33.2 | −2.4 | Culbertson | 81 | 1 | Harrison | −14 | 18 | 1.36 | +0.26 | Drexel | 4.70 | Mitchell | 0.14 |
| Nevada | 40.1 | −1.9 | Las Vegas | 85 | 31 | San Jacinto | −2 | 4 | 0.24 | −0.64 | Lamoille | 0.99 | 6 stations | 0.00 |
| New England | 26.4 | −3.7 | Voluntown, Conn | 75 | 23 | Pittsburg, N. H | −36 | 9 | 2.98 | −0.72 | Nantucket, Mass | 6.46 | Bennington, Vt | 1.03 |
| New Jersey | 38.0 | −0.7 | Bridgeton | 81 | 23 | Layton | −3 | 9 | 4.09 | +0.16 | Cape May City | 6.73 | Sussex | 2.13 |
| New Mexico | 39.6 | −3.5 | Carlsbad | 82 | 25 | Red River Canyon | −14 | 16 | 0.87 | −0.01 | Aspen Grove Ranch. | 2.80 | 2 stations | 0.00 |
| New York | 28.4 | −3.1 | Flushing | 78 | 23 | Indian Lake | −30 | 9 | 2.42 | −0.38 | North Lake | 5.85 | Lauterbrunnen | 0.61 |
| North Carolina | 51.2 | +1.3 | 2 stations | 86 | 4 | Parker | 5 | 20 | 5.27 | +1.09 | Andrews | 8.60 | Belhaven | 2.51 |
| North Dakota | 18.3 | −4.3 | Bowman | 65 | [2] 1 | Willow City | −35 | 18 | 0.41 | −0.42 | Hansboro | 1.68 | Carson | T. |
| Ohio | 37.7 | −1.6 | 2 stations | 77 | 3 | Madison | −2 | 8 | 3.00 | −0.42 | Wilmington | 5.92 | Canton | 1.62 |
| Oklahoma | 48.2 | −3.8 | 2 stations | 87 | [2] 2 | 2 stations | 3 | [2] 18 | 2.40 | +0.43 | Meekers | 5.80 | Hooker | 0.39 |
| Oregon | 42.0 | 0.0 | 2 stations | 87 | 28 | Ukiah | −8 | 4 | 1.95 | −1.27 | Government Camp | 12.36 | Milton | 0.00 |
| Pennsylvania | 37.0 | −0.3 | 3 stations | 80 | 23 | Saegerstown | −8 | 8 | 2.49 | −0.95 | Phoenixville | 5.21 | Lawrenceville | 0.70 |
| Porto Rico | 73.2 | −0.7 | Mayaguez | 92 | 31 | Lares | 46 | 2 | 2.13 | −1.41 | Arecibo | 6.00 | 2 stations | 0.00 |
| South Carolina | 56.2 | +1.2 | Georgetown | 88 | 5 | Walhalla | 17 | 20 | 5.14 | +1.16 | Greenwood | 7.85 | Charleston | 2.38 |
| South Dakota | 27.6 | −3.0 | Wagner | 76 | 1 | St. Francis | −25 | 18 | 0.66 | −0.34 | Deadwood | 3.30 | 2 stations | T. |
| Tennessee | 48.8 | −0.9 | 2 stations | 81 | [2] 4 | Crossville | 9 | 20 | 7.59 | +2.25 | Paris | 10.55 | Copperhill | 4.24 |
| Texas | 54.8 | −4.1 | Mission | 99 | 11 | Dalhart | 4 | 18 | 3.02 | +1.04 | Matagorda | 11.21 | Dundee | 0.19 |
| Utah | 34.1 | −5.1 | St. George | 78 | 30 | Pine View | −25 | | 1.06 | −0.34 | Silver Lake | 5.25 | Wendover | 0.00 |
| Virginia | 46.7 | +1.3 | Diamond Springs | 85 | [2] 13 | Burkes Garden | 5 | 20 | 5.05 | +1.23 | Stuart | 9.42 | Mount Weather | 1.43 |
| Washington | 40.9 | −0.1 | Mottinger | 86 | 29 | Snyders Ranch | −3 | 3 | 1.99 | −0.90 | Quiniault | 9.98 | 3 stations | 0.00 |
| West Virginia | 41.7 | −0.8 | Moorefield | 82 | [2] 12 | Cheat Bridge | −4 | 9 | 3.23 | −0.61 | Pickens | 5.50 | Upper Tract | 0.88 |
| Wisconsin | 21.5 | −7.5 | 2 stations | 65 | 2 | Long Lake | −37 | 19 | 2.32 | +0.67 | Fond du Lac | 6.47 | Amery | 0.67 |
| Wyoming | 25.1 | −5.4 | Lovell | 72 | 30 | Foxpark | −36 | 18 | 1.18 | +0.14 | Hunter's Station | 4.39 | Lovell | 0.11 |

[1] For description of tables and charts, see REVIEW, July, 1922, pp. 384-385.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, March, 1923.*

| Districts and stations. | Elevation of instruments. | | | Pressure. | | | Temperature of the air. | | | | | | | | | | | | Precipitation. | | | Wind. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer above sea level. | Thermometer above ground. | Anemometer above ground. | Station, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hours. | Departure from normal. | Mean max. + mean min. ÷ 2. | Departure from normal. | Maximum. | Date. | Mean maximum. | Minimum. | Date. | Mean minimum. | Greatest daily range. | Mean wet thermometer. | Mean temperature of the dew point. | Mean relative humidity. | Total. | Departure from normal. | Days with .01 inch, or more. | Total movement. | Prevailing direction. | Maximum velocity: Miles per hour. | Maximum velocity: Direction. | Maximum velocity: Date. | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness, tenths. | Total snowfall. | Snow, sleet, and ice on ground at end of month. |
| | Ft. | Ft. | Ft. | In. | In. | In. | °F. | °F. | °F. | | °F. | °F. | | °F. | °F. | °F. | °F. | % | In. | In. | | Miles. | | | | | | | | 0-10 | In. | In. |
| ***New England.*** | | | | | | | **28.9** | **-3.7** | | | | | | | | | | **71** | **3.33** | **-0.5** | | | | | | | | | | **5.6** | | |
| Eastport | 76 | 67 | 85 | 29.83 | 29.92 | -.01 | 22.3 | -6.6 | 56 | 23 | 30 | -7 | 29 | 14 | 35 | 20 | 15 | 74 | 3.88 | -0.4 | 15 | 9,768 | w. | 58 | ne. | 7 | 9 | 7 | 15 | 6.5 | 32.4 | 24.9 |
| Greenville, Me | 1,070 | 6 | ..... | 28.71 | 29.93 | ..... | 17.6 | ..... | 55 | 23 | 29 | -18 | 29 | 7 | 38 | ..... | ..... | ..... | 3.02 | ..... | 19 | ..... | se. | ..... | ..... | ..... | 9 | 7 | 15 | ..... | 29.5 | 36.0 |
| Portland, Me | 103 | 82 | 117 | 29.85 | 29.98 | +.02 | 26.5 | -5.3 | 63 | 23 | 35 | -3 | 29 | 18 | 33 | 24 | 18 | 69 | 3.96 | +0.2 | 14 | 7,275 | w. | 42 | nw. | 28 | 11 | 7 | 13 | 5.6 | 19.7 | 13.3 |
| Concord | 288 | 70 | 79 | 29.65 | 29.98 | -.02 | 27.1 | -3.7 | 63 | 23 | 38 | -4 | 29 | 16 | 37 | ..... | ..... | ..... | 1.42 | -2.0 | 7 | 4,898 | nw. | 34 | w. | 28 | 13 | 8 | 10 | 4.8 | 12.4 | 0.7 |
| Burlington | 404 | 11 | 48 | 29.52 | 29.98 | -.02 | 22.0 | -5.3 | 55 | 23 | 32 | -10 | 9 | 12 | 37 | ..... | ..... | ..... | 1.79 | 0.0 | 18 | 10,026 | s. | 66 | s. | 16 | 7 | 8 | 16 | 7.0 | 18.0 | 4.2 |
| Northfield | 876 | 12 | 60 | 29.00 | 29.99 | -.01 | 21.4 | -4.8 | 58 | 16 | 34 | -16 | 9 | 8 | 44 | 19 | 14 | 75 | 1.84 | -1.0 | 14 | 6,918 | s. | 38 | se. | 16 | 5 | 10 | 16 | 6.7 | 19.9 | 11.7 |
| Boston | 125 | 115 | 188 | 29.83 | 29.97 | .00 | 33.9 | -1.7 | 67 | 23 | 42 | 4 | 29 | 25 | 28 | 29 | 20 | 58 | 2.49 | -1.6 | 11 | 9,310 | w. | 49 | w. | 28 | 11 | 10 | 10 | 5.5 | 10.6 | 0.0 |
| Nantucket | 12 | 14 | 90 | 29.97 | 29.98 | .00 | 32.9 | -4.1 | 50 | 16 | 40 | 8 | 29 | 26 | 27 | 31 | 27 | 80 | 6.46 | +2.5 | 15 | 13,345 | sw. | 56 | sw. | 16 | 13 | 5 | 13 | 5.5 | 7.0 | 0.0 |
| Block Island | 26 | 11 | 46 | 29.96 | 29.99 | +.01 | 32.6 | -2.8 | 52 | 23 | 39 | 7 | 29 | 27 | 26 | 30 | 27 | 80 | 4.62 | +0.2 | 13 | 15,887 | sw. | 60 | nw. | 7 | 13 | 6 | 12 | 5.1 | 3.2 | 0.0 |
| Providence | 160 | 215 | 251 | 29.82 | 30.00 | +.02 | 33.1 | -2.6 | 69 | 23 | 42 | 4 | 29 | 25 | 30 | 29 | 23 | 66 | 3.14 | -1.5 | 15 | 11,939 | nw. | 62 | nw. | 19 | 12 | 9 | 10 | 5.1 | 2.6 | 0.0 |
| Hartford | 159 | 122 | 140 | 29.83 | 30.01 | +.02 | 33.0 | -2.0 | 66 | 23 | 42 | 4 | 29 | 24 | 29 | 29 | 22 | 65 | 2.96 | -1.4 | 12 | 7,397 | nw. | 35 | w. | 28 | 12 | 7 | 12 | 5.4 | 3.8 | 0.0 |
| New Haven | 106 | 74 | 153 | 29.90 | 30.03 | +.04 | 33.8 | -2.0 | 71 | 23 | 42 | 7 | 29 | 26 | 30 | 30 | 24 | 71 | 4.04 | -0.4 | 10 | 7,856 | nw. | 43 | nw. | 28 | 16 | 5 | 10 | 4.5 | 6.0 | 0.0 |
| ***Middle Atlantic States.*** | | | | | | | **40.8** | **+0.4** | | | | | | | | | | **69** | **3.90** | **+0.3** | | | | | | | | | | **5.1** | | |
| Albany | 97 | 102 | 115 | 29.91 | 30.02 | +.02 | 29.6 | -3.1 | 61 | 23 | 39 | 0 | 29 | 20 | 36 | 26 | 21 | 72 | 1.09 | -1.6 | 9 | 7,078 | nw. | 40 | s. | 16 | 14 | 5 | 12 | 5.1 | 5.8 | T. |
| Binghamton | 871 | 10 | 84 | 29.03 | 29.98 | -.04 | 31.7 | -0.3 | 59 | 4 | 41 | 6 | 28 | 22 | 35 | ..... | ..... | ..... | 1.26 | -1.4 | 9 | 6,105 | nw. | 44 | s. | 16 | 5 | 13 | 13 | 6.8 | 7.5 | T. |
| New York | 314 | 414 | 454 | 29.68 | 30.03 | +.03 | 37.0 | -0.7 | 73 | 23 | 46 | 10 | 29 | 28 | 34 | 32 | 26 | 68 | 4.08 | 0.0 | 9 | 16,369 | nw. | 74 | nw. | 19 | 8 | 12 | 11 | 5.9 | 6.2 | 0.0 |
| Harrisburg | 374 | 94 | 104 | 29.65 | 30.06 | +.03 | 38.4 | +0.6 | 71 | 4 | 48 | 14 | 29 | 29 | 34 | 33 | 26 | 65 | 1.83 | -1.3 | 10 | 6,263 | nw. | 40 | nw. | 19 | 9 | 11 | 11 | 5.7 | 4.4 | 0.0 |
| Philadelphia | 114 | 123 | 190 | 29.93 | 30.06 | +.04 | 41.2 | +0.4 | 77 | 23 | 51 | 14 | 29 | 32 | 33 | 36 | 29 | 64 | 3.58 | +0.1 | 9 | 9,037 | nw. | 38 | nw. | 19 | 13 | 8 | 10 | 5.3 | 3.2 | 0.0 |
| Reading | 325 | 81 | 98 | 29.68 | 30.04 | ..... | 38.8 | ..... | 74 | 23 | 48 | 12 | 29 | 30 | 32 | 34 | 28 | 69 | 3.56 | 0.0 | 9 | 6,159 | nw. | 37 | nw. | 19 | 15 | 7 | 9 | 4.5 | 4.7 | 0.0 |
| Scranton | 805 | 111 | 119 | 29.14 | 30.03 | +.01 | 34.2 | -0.7 | 62 | 3 | 43 | 7 | 29 | 25 | 30 | 30 | 26 | 75 | 1.65 | -1.5 | 9 | 6,766 | s. | 40 | w. | 28 | 5 | 14 | 12 | 6.6 | 5.8 | 0.0 |
| Atlantic City | 52 | 37 | 172 | 29.99 | 30.05 | +.03 | 39.6 | +1.0 | 73 | 3 | 47 | 15 | 29 | 32 | 35 | 36 | 31 | 73 | 6.31 | +2.6 | 11 | 15,714 | nw. | 58 | nw. | 7 | 14 | 9 | 8 | 4.5 | 5.1 | 0.0 |
| Cape May | 18 | 13 | 49 | 30.06 | 30.08 | +.07 | 40.7 | -0.1 | 71 | 3 | 48 | 18 | 29 | 34 | 34 | 37 | 33 | 80 | 6.73 | +3.0 | 14 | 6,816 | nw. | 42 | nw. | 31 | 17 | 6 | 8 | 4.2 | 7.5 | 0.0 |
| Sandy Hook | 22 | 10 | 55 | 30.01 | 30.03 | ..... | 36.4 | ..... | 73 | 23 | 44 | 13 | 29 | 29 | 29 | 33 | 29 | 79 | 3.56 | ..... | 11 | 12,722 | nw. | 73 | s. | 16 | 11 | 9 | 11 | 5.8 | 4.6 | 0.0 |
| Trenton | 190 | 159 | 183 | 29.83 | 30.04 | ..... | 38.3 | ..... | 76 | 23 | 48 | 11 | 29 | 29 | 31 | 33 | 27 | 67 | 3.70 | -0.3 | 9 | 10,454 | nw. | 58 | s. | 16 | 9 | 11 | 11 | 5.5 | 4.8 | 0.0 |
| Baltimore | 123 | 100 | 113 | 29.92 | 30.06 | +.03 | 44.5 | +2.2 | 80 | 4 | 55 | 18 | 29 | 34 | 37 | 37 | 30 | 62 | 4.12 | +0.2 | 10 | 5,362 | sw. | 25 | sw. | 4 | 17 | 5 | 9 | 4.5 | 6.2 | 0.0 |
| Washington | 112 | 62 | 85 | 29.94 | 30.06 | +.02 | 45.4 | +2.8 | 80 | 4 | 57 | 18 | 29 | 34 | 38 | 38 | 29 | 60 | 4.47 | +0.6 | 10 | 6,785 | nw. | 36 | n. | 31 | 14 | 7 | 10 | 4.8 | 6.5 | 0.0 |
| Lynchburg | 681 | 153 | 188 | 29.32 | 30.07 | +.02 | 47.9 | +0.6 | 78 | 3 | 60 | 19 | 20 | 36 | 42 | 40 | 33 | 62 | 5.91 | +2.1 | 9 | 7,712 | sw. | 40 | nw. | 19 | 16 | 7 | 8 | 4.5 | 0.0 | 0.0 |
| Norfolk | 91 | 170 | 205 | 29.98 | 30.09 | +.06 | 49.6 | +1.4 | 80 | 23 | 60 | 24 | 20 | 39 | 37 | 44 | 38 | 69 | 5.12 | +0.8 | 10 | 11,518 | sw. | 56 | w. | 13 | 11 | 10 | 10 | 5.3 | T. | 0.0 |
| Richmond | 144 | 11 | 52 | 29.92 | 30.08 | +.04 | 48.0 | +1.1 | 81 | 23 | 60 | 22 | 20 | 36 | 42 | 41 | 35 | 67 | 5.88 | +2.2 | 12 | 8,153 | sw. | 45 | sw. | 12 | 17 | 7 | 7 | 4.0 | 0.0 | 0.0 |
| Wytheville | 2,304 | 49 | 55 | 27.66 | 30.08 | +.03 | 43.3 | +1.0 | 72 | 12 | 54 | 13 | 20 | 32 | 35 | 37 | 31 | 67 | 3.03 | +1.4 | 10 | 6,379 | w. | 43 | w. | 12 | 16 | 6 | 9 | 4.2 | T. | 0.0 |
| ***South Atlantic States.*** | | | | | | | **56.1** | **+2.1** | | | | | | | | | | **72** | **3.56** | **-0.6** | | | | | | | | | | **5.2** | | |
| Asheville | 2,255 | 70 | 84 | 27.71 | 30.10 | +.04 | 47.0 | +2.1 | 78 | 12 | 58 | 13 | 20 | 36 | 38 | 40 | 32 | 63 | 4.96 | +1.0 | 11 | 8,947 | nw. | 42 | n. | 6 | 12 | 9 | 10 | 5.1 | T. | 0.0 |
| Charlotte | 779 | 55 | 62 | 29.24 | 30.09 | +.04 | 52.6 | +2.2 | 78 | 23 | 62 | 23 | 20 | 43 | 33 | 46 | 39 | 66 | 5.84 | +1.3 | 11 | 4,765 | sw. | 26 | w. | 23 | 12 | 6 | 13 | 5.6 | 0.0 | 0.0 |
| Hatteras | 11 | 12 | 53 | 30.08 | 30.09 | +.05 | 53.3 | +1.3 | 71 | 22 | 61 | 32 | 20 | 46 | 28 | 50 | 46 | 80 | 3.42 | -2.0 | 11 | 11,455 | sw. | 66 | w. | 7 | 10 | 11 | 10 | 5.4 | 0.0 | 0.0 |
| Manteo | 12 | 5 | 42 | ..... | ..... | ..... | 50.0 | ..... | 80 | 22 | ..... | 26 | 20 | ..... | 36 | ..... | ..... | ..... | 2.72 | ..... | 6 | ..... | n. | ..... | ..... | ..... | 10 | 7 | 14 | ..... | 0.0 | 0.0 |
| Raleigh | 376 | 103 | 110 | 29.68 | 30.09 | +.04 | 51.6 | +1.2 | 80 | 23 | 62 | 22 | 20 | 41 | 34 | 45 | 40 | 69 | 3.67 | -0.6 | 11 | 7,329 | sw. | 37 | sw. | 16 | 12 | 10 | 9 | 5.0 | 0.0 | 0.0 |
| Wilmington | 78 | 81 | 91 | 30.03 | 30.11 | +.06 | 57.0 | +3.7 | 80 | 5 | 66 | 29 | 20 | 48 | 33 | 51 | 47 | 77 | 4.09 | +0.5 | 10 | 7,207 | sw. | 38 | sw. | 7 | 14 | 7 | 10 | 4.5 | 0.0 | 0.0 |
| Charleston | 48 | 11 | 92 | 30.06 | 30.11 | +.05 | 59.6 | +2.2 | 84 | 5 | 67 | 33 | 20 | 52 | 29 | 54 | 50 | 76 | 2.38 | -1.3 | 12 | 9,370 | sw. | 43 | w. | 6 | 14 | 4 | 13 | 5.5 | 0.0 | 0.0 |
| Columbia, S. C | 351 | 41 | 57 | 29.72 | 30.11 | +.05 | 56.8 | +2.8 | 82 | 23 | 67 | 27 | 20 | 47 | 34 | 49 | 43 | 68 | 3.30 | -0.4 | 10 | 6,337 | ne. | 38 | s. | 6 | 14 | 5 | 12 | 5.2 | 0.0 | 0.0 |
| Due West | 711 | 10 | 55 | 29.34 | 30.12 | ..... | 54.0 | ..... | 80 | 23 | 64 | 24 | 20 | 44 | 33 | ..... | ..... | ..... | 6.34 | ..... | 10 | 7,378 | sw. | 42 | sw. | 6 | 11 | 6 | 14 | 5.5 | 0.0 | 0.0 |
| Greenville, S. C | 1,039 | 113 | 122 | 28.97 | 30.08 | ..... | 53.0 | ..... | 76 | 23 | 63 | 22 | 20 | 43 | 34 | 45 | 39 | 67 | 5.81 | ..... | 9 | 7,204 | sw. | 46 | sw. | 23 | 12 | 7 | 12 | 5.2 | 0.0 | 0.0 |
| Augusta | 180 | 62 | 77 | 29.90 | 30.10 | +.04 | 57.9 | +1.9 | 83 | 5 | 68 | 29 | 20 | 48 | 34 | 52 | 48 | 75 | 4.46 | -0.4 | 12 | 4,368 | nw. | 31 | s. | 6 | 11 | 8 | 12 | 5.5 | 0.0 | 0.0 |
| Savannah | 65 | 150 | 194 | 30.04 | 30.11 | +.05 | 60.9 | +1.9 | 84 | 5 | 70 | 32 | 20 | 52 | 41 | 54 | 50 | 76 | 2.31 | -1.3 | 11 | 10,000 | s. | 48 | w. | 6 | 12 | 8 | 11 | 5.2 | 0.0 | 0.0 |
| Jacksonville | 43 | 209 | 245 | 30.06 | 30.11 | +.05 | 64.6 | +2.0 | 84 | 12 | 73 | 34 | 20 | 56 | 38 | 58 | 55 | 79 | 1.15 | -2.4 | 11 | 9,922 | sw. | 54 | sw. | 6 | 12 | 10 | 9 | 4.7 | 0.0 | 0.0 |
| ***Florida Peninsula.*** | | | | | | | **73.1** | **+2.8** | | | | | | | | | | **75** | **0.68** | **-1.6** | | | | | | | | | | **3.3** | | |
| Key West | 22 | 10 | 64 | 30.05 | 30.07 | +.02 | 76.2 | +3.6 | 85 | 13 | 81 | 63 | 1 | 71 | 14 | 69 | 66 | 76 | 0.39 | -1.1 | 4 | 8,595 | se. | 28 | n. | 1 | 25 | 5 | 1 | 2.4 | 0.0 | 0.0 |
| Miami | 25 | 71 | 79 | 30.08 | 30.11 | ..... | 73.8 | +1.8 | 84 | 7 | 79 | 48 | 2 | 69 | 25 | 67 | 64 | 73 | 0.58 | -2.1 | 6 | 6,993 | se. | 26 | e. | 10 | 18 | 10 | 3 | 3.7 | 0.0 | 0.0 |
| Sand Key | 23 | 39 | 72 | 30.05 | 30.08 | +.03 | 74.2 | ..... | 82 | 29 | 76 | 64 | 1 | 72 | 10 | 69 | 66 | 76 | 0.36 | ..... | 5 | 11,510 | se. | 34 | se. | 15 | 24 | 7 | 0 | 2.4 | 0.0 | 0.0 |
| Tampa | 35 | 79 | 87 | 30.06 | 30.10 | +.03 | 69.3 | +3.0 | 87 | 21 | 78 | 48 | 9 | 60 | 30 | 62 | 58 | 75 | 1.08 | -1.7 | 5 | 5,171 | e. | 23 | sw. | 19 | 11 | 14 | 6 | 4.6 | 0.0 | 0.0 |
| ***East Gulf States.*** | | | | | | | **56.8** | **-0.5** | | | | | | | | | | **73** | **6.00** | **+0.2** | | | | | | | | | | **5.7** | | |
| Atlanta | 1,174 | 190 | 216 | 28.85 | 30.10 | +.04 | 52.1 | +0.1 | 75 | 6 | 62 | 17 | 20 | 42 | 33 | 46 | 40 | 68 | 5.14 | -0.6 | 13 | 10,438 | nw. | 52 | nw. | 19 | 12 | 4 | 15 | 5.8 | 0.0 | 0.0 |
| Macon | 370 | 78 | 87 | 29.71 | 30.12 | +.06 | 57.2 | +2.4 | 81 | 23 | 68 | 23 | 20 | 47 | 35 | 49 | 44 | 68 | 6.33 | +0.8 | 12 | 5,758 | nw. | 39 | s. | 6 | 12 | 4 | 15 | 5.6 | 0.0 | 0.0 |
| Thomasville | 273 | 49 | 58 | 29.81 | 30.11 | +.05 | 61.0 | +0.8 | 81 | 26 | 71 | 29 | 20 | 51 | 38 | 55 | 52 | 80 | 5.23 | +0.1 | 12 | 4,408 | sw. | 32 | sw. | 6 | 6 | 8 | 17 | 6.7 | 0.0 | 0.0 |
| Apalachicola | 36 | 42 | 49 | 30.07 | 30.11 | ..... | 61.4 | ..... | 76 | 26 | 68 | 33 | 20 | 55 | 33 | 57 | 54 | 82 | 2.37 | ..... | 8 | 7,055 | s. | 30 | nw. | 6 | 13 | 8 | 10 | 4.7 | 0.0 | 0.0 |
| Pensacola | 56 | 149 | 185 | 30.05 | 30.11 | +.05 | 59.3 | -1.0 | 76 | 27 | 66 | 30 | 20 | 53 | 34 | 56 | 53 | 82 | 4.99 | -0.4 | 9 | 11,080 | s. | 46 | sw. | 6 | 10 | 7 | 14 | 5.8 | 0.0 | 0.0 |
| Anniston | 741 | 9 | 57 | 29.33 | 30.13 | +.07 | 53.0 | +0.5 | 80 | 12 | 65 | 19 | 20 | 41 | 36 | ..... | ..... | ..... | 5.25 | -0.5 | 15 | 5,573 | nw. | 30 | sw. | 12 | 9 | 11 | 11 | 5.3 | T. | 0.0 |
| Birmingham | 700 | 11 | 48 | 29.36 | 30.14 | +.08 | 54.0 | -1.2 | 81 | 12 | 65 | 21 | 20 | 43 | 34 | 45 | 38 | 62 | 5.15 | -0.6 | 16 | 6,807 | n. | 45 | s. | 11 | 12 | 7 | 12 | 5.2 | T. | 0.0 |
| Mobile | 57 | 125 | 161 | 30.04 | 30.10 | +.04 | 58.8 | -1.2 | 79 | 23 | 67 | 30 | 20 | 50 | 27 | 53 | 49 | 78 | 6.09 | -1.1 | 10 | 8,811 | s. | 39 | sw. | 6 | 8 | 9 | 14 | 6.1 | 0.0 | 0.0 |
| Montgomery | 223 | 100 | 112 | 29.87 | 30.13 | +.07 | 57.0 | -0.8 | 81 | 22 | 67 | 25 | 20 | 47 | 33 | 50 | 44 | 68 | 7.27 | +0.9 | 12 | 5,677 | n. | 36 | sw. | 6 | 11 | 8 | 12 | 5.3 | 0.0 | 0.0 |
| Corinth | 469 | 6 | ..... | ..... | ..... | ..... | 51.8 | ..... | 78 | 4 | 64 | 18 | 19 | 40 | 40 | ..... | ..... | ..... | 7.70 | ..... | 12 | ..... | n. | ..... | ..... | ..... | 11 | 9 | 11 | ..... | 0.0 | 0.0 |
| Meridian | 375 | 85 | 93 | 29.70 | 30.11 | +.06 | 55.2 | -1.1 | 83 | 4 | 66 | 25 | 19 | 45 | 35 | 48 | 42 | 68 | 8.46 | +2.8 | 14 | 5,328 | ne. | 31 | w. | 6 | 10 | 8 | 13 | 5.5 | 0.0 | 0.0 |
| Vicksburg | 247 | 65 | 73 | 29.83 | 30.12 | +.08 | 56.0 | -2.5 | 82 | 4 | 65 | 24 | 19 | 47 | 30 | 49 | 44 | 72 | 7.48 | +1.2 | 12 | 6,494 | se. | 38 | w. | 11 | 9 | 6 | 16 | 6.1 | 0.0 | 0.0 |
| New Orleans | 53 | 76 | 84 | 30.04 | 30.09 | +.05 | 61.6 | -1.2 | 82 | 4 | 70 | 33 | 20 | 53 | 28 | 55 | 51 | 74 | 4.56 | -0.7 | 14 | 6,492 | ne. | 32 | sw. | 6 | 8 | 7 | 16 | 6.3 | 0.0 | 0.0 |
| ***West Gulf States.*** | | | | | | | **54.7** | **-3.3** | | | | | | | | | | **70** | **3.28** | **+0.2** | | | | | | | | | | **5.4** | | |
| Shreveport | 249 | 77 | 93 | 29.82 | 30.10 | +.08 | 55.0 | -3.2 | 76 | 22 | 65 | 21 | 19 | 45 | 35 | 48 | 41 | 67 | 3.63 | -0.9 | 13 | 6,823 | se. | 39 | nw. | 15 | 12 | 7 | 12 | 5.2 | T. | 0.0 |
| Bentonville | 1,303 | 11 | 44 | ..... | ..... | ..... | 44.4 | -2.9 | 74 | 2 | 56 | 4 | 19 | 33 | 37 | ..... | ..... | ..... | 4.06 | ..... | 7 | ..... | ..... | ..... | ..... | ..... | 14 | 6 | 11 | ..... | 0.4 | 0.0 |
| Fort Smith | 457 | 79 | 94 | 29.56 | 30.05 | +.04 | 48.7 | -2.6 | 75 | 2 | 59 | 10 | 19 | 38 | 33 | 42 | 34 | 63 | 2.12 | -1.5 | 5 | 7,818 | e. | 57 | sw. | 11 | 10 | 6 | 15 | 5.9 | T. | 0.0 |
| Little Rock | 357 | 136 | 144 | 29.68 | 30.06 | +.03 | 49.6 | -3.4 | 74 | 3 | 60 | 14 | 19 | 39 | 32 | 44 | 38 | 70 | 5.00 | +0.1 | 9 | 8,286 | s. | 45 | sw. | 11 | 12 | 6 | 13 | 5.5 | 0.0 | 0.0 |
| Brownsville | 57 | 53 | 61 | 29.96 | 30.02 | ..... | 65.0 | ..... | 84 | 22 | 72 | 39 | 19 | 58 | 35 | 59 | 55 | 79 | 1.32 | ..... | 8 | 8,563 | s. | 37 | s. | 11 | 8 | 15 | 8 | 5.3 | 0.0 | 0.0 |
| Corpus Christi | 20 | 11 | 73 | 30.02 | 30.04 | +.07 | 62.6 | -1.8 | 87 | 11 | 69 | 31 | 19 | 56 | 32 | 57 | 52 | 73 | 2.28 | +0.4 | 10 | 11,338 | n. | 49 | s. | 15 | 9 | 9 | 13 | 6.3 | 0.0 | 0.0 |
| Dallas | 512 | 109 | 117 | 29.52 | 30.07 | ..... | 53.2 | ..... | 77 | 3 | 64 | 16 | 19 | 42 | 34 | ..... | ..... | ..... | 1.62 | ..... | 10 | 8,724 | nw. | 54 | sw. | 11 | 11 | 11 | 9 | 5.0 | 0.0 | 0.0 |
| Fort Worth | 670 | 106 | 114 | 29.33 | 30.05 | +.07 | 53.6 | -3.0 | 80 | 21 | 65 | 15 | 19 | 42 | 36 | 44 | 36 | 60 | 1.52 | -0.2 | 8 | 8,659 | se. | 42 | sw. | 11 | 14 | 8 | 9 | 4.5 | 0.0 | 0.0 |
| Galveston | 54 | 106 | 114 | 30.02 | 30.08 | +.07 | 59.6 | -2.8 | 79 | 12 | 65 | 30 | 19 | 54 | 28 | 56 | 53 | 83 | 4.53 | +1.6 | 11 | 10,023 | se. | 39 | nw. | 18 | 12 | 6 | 13 | 5.9 | 0.0 | 0.0 |
| Groesbeck | 461 | 11 | 56 | 29.56 | 30.05 | ..... | 53.6 | ..... | 77 | 3 | 63 | 20 | 19 | 44 | 38 | ..... | ..... | ..... | 3.70 | ..... | 10 | 11,225 | s. | 50 | sw. | 11 | 11 | 9 | 11 | 5.0 | 0.0 | 0.0 |
| Houston | 138 | 111 | 121 | 29.91 | 30.06 | ..... | 59.8 | -3.7 | 83 | 22 | 68 | 24 | 20 | 51 | 35 | ..... | ..... | ..... | 5.37 | ..... | 11 | 7,792 | se. | 36 | nw. | 15 | 11 | 6 | 14 | 5.5 | T. | 0.0 |
| Palestine | 510 | 64 | 72 | 29.54 | 30.08 | +.08 | 54.2 | -4.9 | 76 | 3 | 64 | 20 | 19 | 45 | 38 | 48 | 42 | 67 | 4.12 | +0.6 | 12 | 7,846 | s. | 36 | sw. | 11 | 9 | 8 | 14 | 5.6 | 0.0 | 0.0 |
| Port Arthur | 34 | 58 | 66 | 30.02 | 30.06 | ..... | 58.8 | ..... | 81 | 12 | 66 | 28 | 20 | 52 | 27 | 54 | 50 | 79 | 5.97 | ..... | 11 | 8,589 | se. | 38 | sw. | 11 | 10 | 8 | 13 | 5.7 | 0.0 | 0.0 |
| San Antonio | 701 | 119 | 132 | 29.31 | 30.04 | +.06 | 58.6 | -3.5 | 82 | 21 | 69 | 28 | 19 | 48 | 37 | 50 | 42 | 60 | 3.07 | +1.4 | 5 | 7,765 | ne. | 48 | nw. | 15 | 13 | 6 | 12 | 5.2 | 0.0 | 0.0 |
| Taylor | 582 | 55 | 63 | 29.46 | 30.07 | +.08 | 55.4 | -4.3 | 79 | 21 | 66 | 23 | 20 | 44 | 39 | ..... | ..... | ..... | 3.23 | +0.6 | 7 | 8,527 | n. | 44 | sw. | 11 | 9 | 9 | 13 | 5.5 | 0.0 | 0.0 |

TABLE 1.—*Climatological data for Weather Bureau stations, March, 1923*—Continued.

| Districts and stations. | Elevation of instruments: Barometer above sea level. | Thermometer above ground. | Anemometer above ground. | Pressure: Station, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hours. | Departure from normal. | Temperature of the air: Mean max.+mean min.÷2. | Departure from normal. | Maximum. | Date. | Mean maximum. | Minimum. | Date. | Mean minimum. | Greatest daily range. | Mean wet thermometer. | Mean temperature of the dew point. | Mean relative humidity. | Precipitation: Total. | Departure from normal. | Days with 0.01 inch, or more. | Wind: Total movement. | Prevailing direction. | Maximum velocity: Miles per hour | Direction. | Date. | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness, tenths. | Total snowfall. | Snow, sleet, and ice on ground at end of month. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ft. | Ft. | Ft. | In. | In. | In. | °F. | °F. | °F. | | °F. | °F. | | °F. | °F. | °F. | °F. | % | In. | In. | | Miles. | | | | | | | | 0-10 | In. | In. |
| ***Ohio Valley and Tennessee.*** | | | | | | | **43.0** | **−1.0** | | | | | | | | | | **68** | **4.48** | **+0.1** | | | | | | | | | | **5.8** | | |
| Chattanooga | 762 | 189 | 213 | 29.30 | 30.12 | +.03 | 51.4 | +0.2 | 80 | 12 | 62 | 18 | 20 | 40 | 33 | 43 | 35 | 59 | 6.69 | +0.5 | 12 | 7,713 | nw. | 62 | s. | 12 | 11 | 10 | 10 | 5.2 | T. | 0.0 |
| Knoxville | 996 | 102 | 111 | 29.03 | 30.10 | +.04 | 49.0 | +0.3 | 78 | 12 | 60 | 16 | 20 | 38 | 37 | 42 | 35 | 61 | 7.82 | +2.2 | 13 | 6,042 | sw. | 58 | sw. | 12 | 9 | 3 | 19 | 6.5 | T. | 0.0 |
| Memphis | 399 | 76 | 97 | 29.66 | 30.10 | +.07 | 49.8 | +2.5 | 75 | 22 | 59 | 14 | 19 | 40 | 38 | 43 | 37 | 66 | 7.03 | +1.3 | 9 | 8,373 | n. | 56 | sw. | 11 | 10 | 7 | 14 | 5.8 | T. | 0.0 |
| Nashville | 546 | 168 | 191 | 29.52 | 30.12 | +.07 | 47.6 | −1.6 | 74 | 3 | 59 | 13 | 19 | 35 | 38 | 42 | 36 | 69 | 7.69 | +2.2 | 11 | 9,666 | nw. | 72 | sw. | 11 | 12 | 5 | 14 | 5.3 | T. | 0.0 |
| Lexington | 989 | 193 | 230 | 29.00 | 30.10 | +.05 | 42.6 | −0.8 | 71 | 3 | 54 | 14 | 20 | 31 | 35 | .... | .... | .... | 4.65 | −0.1 | 11 | 13,129 | sw. | 63 | sw. | 12 | 11 | 8 | 12 | 5.4 | 0.1 | 0.0 |
| Louisville | 525 | 219 | 255 | 29.50 | 30.10 | +.05 | 43.4 | −2.0 | 71 | 3 | 51 | 12 | 19 | 33 | 39 | 37 | 29 | 60 | 4.18 | −0.1 | 9 | 11,760 | s. | 66 | sw. | 12 | 11 | 10 | 10 | 5.2 | T. | 0.0 |
| Evansville | 431 | 139 | 175 | 29.62 | 30.10 | +.06 | 43.0 | −1.6 | 70 | 3 | 53 | 10 | 19 | 33 | 45 | 37 | 31 | 67 | 2.48 | −2.1 | 11 | 11,281 | sw. | 60 | sw. | 11 | 8 | 16 | 7 | 5.4 | T. | 0.0 |
| Indianapolis | 822 | 194 | 230 | 29.15 | 30.07 | +.02 | 38.2 | −1.8 | 68 | 2 | 48 | 7 | 19 | 28 | 45 | 33 | 28 | 70 | 4.41 | +0.4 | 14 | 11,608 | nw. | 60 | sw. | 12 | 6 | 9 | 16 | 6.4 | 1.1 | T. |
| Royal Center | 733 | 11 | 55 | 29.21 | 30.03 | ..... | 33.6 | ..... | 63 | 2 | 44 | 4 | 19 | 23 | 42 | .... | .... | .... | 3.70 | ..... | 13 | 10,385 | sw. | 50 | w. | 4 | 6 | 13 | 12 | 6.2 | 7.5 | .00 |
| Terre Haute | 575 | 96 | 129 | 29.43 | 30.06 | ..... | 39.7 | ..... | 70 | 2 | 50 | 5 | 19 | 29 | 47 | 34 | 29 | 72 | 5.05 | ..... | 13 | 10,033 | nw. | 56 | sw. | 12 | 9 | 15 | 7 | 5.6 | 0.2 | 0.0 |
| Cincinnati | 628 | 11 | 51 | 29.38 | 30.08 | +.03 | 40.4 | −0.5 | 68 | 3 | 51 | 14 | 31 | 29 | 37 | .... | 33 | 77 | 3.50 | −0.1 | 11 | 7,832 | sw. | 48 | sw. | 12 | 10 | 9 | 12 | 5.5 | 1.0 | 0.0 |
| Columbus | 824 | 179 | 222 | 29.16 | 30.06 | +.02 | 37.8 | −1.3 | 65 | 4 | 48 | 9 | 31 | 28 | 37 | 32 | 27 | 71 | 3.01 | −0.2 | 14 | 10,952 | nw. | 60 | w. | 4 | 7 | 15 | 9 | 5.9 | 3.5 | 0.0 |
| Dayton | 899 | 181 | 216 | 29.08 | 30.06 | ..... | 38.4 | −1.9 | 65 | 2 | 49 | 12 | 31 | 28 | 36 | 33 | 27 | 69 | 2.42 | −1.0 | 13 | 11,118 | sw. | 66 | w. | 12 | 9 | 12 | 10 | 5.5 | 2.0 | 0.0 |
| Elkins | 1,947 | 59 | 67 | 27.97 | 30.08 | +.03 | 39.5 | +0.4 | 74 | 12 | 53 | 10 | 29 | 26 | 44 | 34 | 30 | 75 | 3.32 | −0.8 | 13 | 6,664 | w. | 41 | sw. | 12 | 8 | 9 | 14 | 6.1 | 2.8 | 0.0 |
| Parkersburg | 638 | 77 | 84 | 29.41 | 30.08 | +.03 | 42.1 | −0.2 | 73 | 12 | 54 | 14 | 31 | 30 | 38 | 33 | 29 | 66 | 3.35 | −0.5 | 11 | 6,537 | se. | 43 | w. | 4 | 12 | 7 | 12 | 5.3 | 0.1 | 0.0 |
| Pittsburgh | 842 | 353 | 410 | 29.12 | 30.05 | +.01 | 38.6 | −1.0 | 71 | 12 | 49 | 11 | 31 | 28 | 40 | 33 | 27 | 68 | 2.15 | −0.9 | 14 | 11,264 | nw. | 70 | w. | 4 | 3 | 11 | 17 | 7.4 | 2.4 | 0.0 |
| ***Lower Lake Region.*** | | | | | | | **30.8** | **−2.2** | | | | | | | | | | **71** | **2.31** | **−0.3** | | | | | | | | | | **6.6** | | |
| Buffalo | 767 | 247 | 280 | 29.14 | 29.99 | −.02 | 29.2 | −1.9 | 56 | 4 | 38 | 5 | 29 | 20 | 39 | 26 | 21 | 74 | 1.70 | −0.9 | 17 | 16,028 | w. | 84 | w. | 4 | 2 | 13 | 16 | 7.3 | 10.5 | 0.6 |
| Canton | 448 | 10 | 61 | 29.45 | 29.95 | ..... | 20.6 | −7.1 | 54 | 16 | 31 | −21 | 9 | 10 | 44 | .... | .... | .... | 2.07 | −0.8 | 19 | 9,779 | w. | 59 | sw. | 16 | 13 | 6 | 12 | 5.3 | 17.4 | 4.4 |
| Oswego | 335 | 76 | 91 | ..... | 30.00 | −.02 | 27.8 | −3.4 | 56 | 23 | 36 | 6 | 29 | 20 | 34 | .... | .... | .... | 1.84 | −1.0 | 14 | 10,705 | nw. | 44 | sw. | 16 | 4 | 8 | 19 | .... | 17.8 | 2.0 |
| Rochester | 523 | 86 | 102 | 29.42 | 30.01 | −.01 | 30.0 | −1.8 | 60 | 16 | 39 | 5 | 28 | 21 | 37 | 25 | 19 | 67 | 2.71 | −0.2 | 18 | 8,684 | w. | 54 | w. | 16 | 4 | 9 | 18 | 7.3 | 18.3 | 4.0 |
| Syracuse | 597 | 97 | 113 | 29.33 | 29.99 | −.03 | 29.2 | −2.2 | 60 | 23 | 38 | 2 | 29 | 21 | 36 | .... | .... | .... | 2.91 | +0.5 | 19 | 11,400 | nw. | 65 | s. | 16 | 3 | 11 | 17 | 7.2 | 14.7 | 1.0 |
| Erie | 714 | 130 | 166 | 29.22 | 30.01 | −.01 | 33.4 | −0.1 | 62 | 4 | 43 | 6 | 29 | 24 | 42 | 28 | 22 | 69 | 1.89 | −0.8 | 15 | 11,072 | w. | 59 | w. | 4 | 6 | 13 | 12 | 6.2 | 7.8 | 0.0 |
| Cleveland | 762 | 190 | 201 | 29.18 | 30.03 | .00 | 34.8 | +0.2 | 63 | 4 | 44 | 11 | 31 | 26 | 37 | 30 | 24 | 70 | 1.89 | −0.9 | 17 | 13,177 | nw. | 52 | s. | 16 | 5 | 7 | 19 | 7.3 | 6.1 | T. |
| Sandusky | 629 | 62 | 70 | 29.31 | 30.01 | −.02 | 35.0 | −0.1 | 62 | 2 | 44 | 11 | 31 | 26 | 34 | .... | .... | .... | 2.22 | −0.3 | 17 | 8,610 | sw. | 38 | sw. | 12 | 4 | 14 | 13 | 6.7 | 5.2 | 0.0 |
| Toledo | 628 | 208 | 243 | 29.33 | 30.03 | .00 | 33.8 | −1.5 | 60 | 2 | 43 | 7 | 31 | 25 | 38 | 29 | 23 | 69 | 3.13 | +0.8 | 15 | 13,833 | sw. | 73 | sw. | 12 | 10 | 12 | 9 | 5.5 | 5.5 | 0.0 |
| Fort Wayne | 856 | 113 | 124 | 29.09 | 30.04 | ..... | 33.9 | −5.0 | 63 | 2 | 43 | 7 | 19 | 25 | 41 | 30 | 25 | 73 | 3.65 | ..... | 13 | 9,347 | sw. | 56 | sw. | 12 | 7 | 10 | 14 | 6.5 | 6.3 | 0.0 |
| Detroit | 730 | 218 | 258 | 29.20 | 30.02 | −.01 | 31.6 | −1.8 | 58 | 3 | 41 | 6 | 19 | 22 | 38 | 27 | 23 | 76 | 2.78 | +0.4 | 14 | 10,366 | nw. | 70 | sw. | 12 | 9 | 7 | 15 | 6.3 | 4.7 | 0.0 |
| ***Upper Lake Region.*** | | | | | | | **22.6** | **−5.4** | | | | | | | | | | **79** | **2.70** | **+0.4** | | | | | | | | | | **6.3** | | |
| Alpena | 609 | 13 | 92 | 29.30 | 30.00 | −.03 | 19.4 | −6.1 | 46 | 22 | 29 | −9 | 26 | 10 | 37 | 18 | 15 | 82 | 3.05 | +1.0 | 17 | 11,190 | nw. | 48 | nw. | 27 | 10 | 8 | 13 | 5.8 | 28.8 | 5.7 |
| Escanaba | 612 | 54 | 60 | 29.32 | 30.02 | −.02 | 17.8 | −5.7 | 41 | 2 | 27 | −6 | 19 | 9 | 31 | 16 | 13 | 84 | 2.56 | +0.6 | 12 | 8,825 | nw. | 48 | n. | 12 | 17 | 4 | 10 | 4.6 | 26.7 | 15.5 |
| Grand Haven | 632 | 51 | 89 | 29.29 | 30.00 | −.03 | 27.6 | −4.1 | 49 | 2 | 35 | 0 | 19 | 20 | 31 | 25 | 22 | 82 | 2.88 | +0.4 | 20 | 11,324 | nw. | 56 | w. | 16 | 5 | 6 | 20 | 7.3 | 11.8 | 0.2 |
| Grand Rapids | 707 | 70 | 87 | 29.22 | 30.01 | −.02 | 28.7 | −4.3 | 57 | 2 | 37 | 0 | 19 | 20 | 31 | 25 | 21 | 75 | 2.36 | −0.2 | 16 | 6,291 | w. | 33 | w. | 28 | 5 | 10 | 16 | 6.8 | 9.6 | 0.0 |
| Houghton | 684 | 62 | 99 | 29.26 | 30.02 | −.02 | 15.2 | −8.6 | 46 | 2 | 24 | −13 | 26 | 7 | 46 | .... | .... | .... | 2.36 | +0.3 | 17 | 9,379 | w. | 50 | w. | 9 | 4 | 9 | 18 | 7.0 | 24.5 | 14.8 |
| Lansing | 878 | 11 | 62 | 29.02 | 29.99 | ..... | 28.4 | −2.9 | 56 | 2 | 38 | −1 | 19 | 19 | 35 | 25 | 21 | 78 | 3.04 | +0.8 | 17 | 6,899 | nw. | 34 | sw. | 12 | 7 | 7 | 17 | 6.6 | 12.7 | T. |
| Ludington | 637 | 60 | 66 | 29.28 | 30.00 | ..... | 25.2 | ..... | 49 | 2 | 32 | 2 | 26 | 18 | 30 | 22 | 19 | 82 | 4.04 | ..... | 19 | 10,121 | s. | 41 | nw. | 28 | 7 | 6 | 18 | 6.8 | 23.6 | 2.6 |
| Marquette | 734 | 77 | 111 | 29.21 | 30.04 | .00 | 17.8 | −5.9 | 54 | 2 | 26 | −7 | 28 | 10 | 34 | 14 | 11 | 83 | 3.24 | +1.2 | 17 | 7,482 | nw. | 28 | s. | 9 | 6 | 4 | 21 | 7.2 | 32.4 | 17.5 |
| Port Huron | 638 | 70 | 120 | 29.28 | 30.00 | −.03 | 28.8 | −1.6 | 55 | 4 | 37 | 5 | 31 | 20 | 30 | 25 | 21 | 77 | 2.05 | −0.4 | 15 | 11,163 | nw. | 46 | w. | 16 | 7 | 12 | 12 | 6.1 | 6.5 | T. |
| Saginaw | 641 | 69 | 77 | 29.29 | 30.01 | ..... | 26.0 | ..... | 54 | 2 | 34 | −1 | 19 | 18 | 33 | 24 | 21 | 81 | 1.96 | −0.7 | 14 | 8,051 | nw. | 36 | se. | 12 | 10 | 6 | 15 | 6.4 | 9.3 | T. |
| Sault Sainte Marie | 614 | 11 | 52 | 29.29 | 30.03 | .00 | 13.8 | −7.5 | 42 | 2 | 24 | −15 | 20 | 3 | 26 | 12 | 10 | 86 | 2.58 | +0.7 | 17 | 8,408 | nw. | 54 | nw. | 27 | 7 | 8 | 16 | 6.5 | 27.1 | 25.3 |
| Chicago | 823 | 140 | 310 | 29.12 | 30.03 | .00 | 33.0 | −3.3 | 65 | 2 | 41 | 0 | 19 | 25 | 36 | 29 | 22 | 66 | 3.05 | +0.5 | 13 | 10,864 | nw. | 60 | ne. | 11 | 10 | 8 | 13 | 5.7 | 5.3 | 0.0 |
| Green Bay | 617 | 109 | 144 | 29.31 | 30.00 | −.04 | 22.1 | −4.7 | 52 | 2 | 30 | −5 | 19 | 14 | 31 | 19 | 16 | 79 | 2.93 | +0.5 | 13 | 11,054 | s. | 60 | n. | 12 | 9 | 10 | 12 | 6.0 | 32.1 | 6.5 |
| Milwaukee | 681 | 125 | 139 | 29.25 | 30.01 | −.02 | 27.2 | −4.9 | 61 | 2 | 35 | −3 | 19 | 19 | 37 | 24 | 19 | 73 | 4.42 | +1.8 | 11 | 9,757 | w. | 46 | ne. | 12 | 8 | 11 | 12 | 6.0 | 35.8 | 0.4 |
| Duluth | 1,133 | 11 | 47 | 28.77 | 30.05 | −.01 | 13.5 | −10.2 | 48 | 1 | 23 | −15 | 19 | 4 | 35 | 11 | 8 | 84 | 1.28 | −0.3 | 14 | 11,763 | nw. | 55 | nw. | 30 | 9 | 9 | 13 | 5.8 | 15.7 | 7.5 |
| ***North Dakota.*** | | | | | | | **17.8** | **−4.3** | | | | | | | | | | **77** | **0.44** | **−0.5** | | | | | | | | | | **6.9** | | |
| Moorhead | 940 | 50 | 58 | 29.03 | 30.09 | +.01 | 17.3 | −5.4 | 47 | 26 | 27 | −19 | 18 | 7 | 43 | 15 | 10 | 76 | 0.29 | −0.8 | 5 | 8,124 | n. | 33 | n. | 29 | 5 | 5 | 21 | 7.4 | 4.4 | T. |
| Bismarck | 1,674 | 8 | 57 | 28.25 | 30.11 | +.05 | 21.4 | −2.8 | 54 | 1 | 32 | −16 | 18 | 11 | 43 | 18 | 14 | 74 | 0.28 | −0.8 | 4 | 8,303 | nw. | 36 | nw. | 23 | 8 | 9 | 14 | 6.0 | 3.4 | 0.0 |
| Devils Lake | 1,482 | 11 | 44 | 28.43 | 30.09 | +.04 | 12.4 | −6.1 | 40 | 1 | 23 | −23 | 18 | 1 | 40 | 11 | 8 | 85 | 0.76 | −0.2 | 12 | 9,146 | nw. | 44 | ne. | 17 | 5 | 8 | 18 | 6.1 | 11.8 | 2.0 |
| Ellendale | 1,457 | 10 | 56 | 28.46 | 30.08 | | 20.6 | | 51 | 1 | 31 | −18 | 18 | 10 | 45 | | | | 0.26 | | 4 | 12,670 | nw. | 56 | n. | 17 | 4 | 13 | 14 | 7.0 | 2.9 | 0.0 |
| Grand Forks | 835 | 12 | 89 | | | | 14.1 | | 46 | 26 | 24 | −20 | 18 | 4 | 36 | | | | 0.65 | | 14 | | nw. | 40 | ne. | 26 | 8 | 7 | 16 | | 6.5 | 5.5 |
| Williston | 1,878 | 41 | 48 | 28.00 | 30.06 | +.02 | 20.0 | −2.9 | 54 | 1 | 31 | −15 | 18 | 9 | 37 | 18 | 13 | 74 | 0.44 | −0.2 | 10 | 6,863 | nw. | 35 | ne. | 16 | 4 | 7 | 20 | 7.3 | 6.3 | 0.0 |
| ***Upper Mississippi Valley.*** | | | | | | | **32.0** | **−4.4** | | | | | | | | | | **71** | **3.61** | **+1.2** | | | | | | | | | | **5.6** | | |
| Minneapolis | 918 | 102 | 208 | 29.02 | 30.04 | ..... | 21.4 | ..... | 56 | 1 | 31 | −8 | 18 | 12 | 37 | .... | .... | .... | 1.17 | −0.5 | 10 | 11,012 | n. | 43 | nw. | 30 | 5 | 13 | 13 | 6.6 | 11.8 | T. |
| St. Paul | 837 | 236 | 261 | 29.11 | 30.05 | .00 | 21.0 | −8.1 | 56 | 2 | 31 | −9 | 19 | 11 | 37 | .... | .... | .... | 1.33 | −0.3 | 9 | 11,128 | nw. | 48 | nw. | 29 | 8 | 13 | 10 | 5.4 | 14.1 | T. |
| La Crosse | 714 | 11 | 48 | 29.23 | 30.03 | −.01 | 24.2 | −7.3 | 65 | 2 | 34 | −12 | 19 | 14 | 36 | .... | .... | .... | 2.63 | +1.0 | 11 | 5,084 | nw. | 21 | w. | 23 | 10 | 5 | 16 | 6.2 | 26.1 | 0.0 |
| Madison | 974 | 70 | 78 | 28.95 | 30.05 | +.01 | 24.7 | −5.9 | 60 | 2 | 33 | −8 | 19 | 16 | 32 | 22 | 18 | 77 | 4.14 | +1.9 | 12 | 9,194 | nw. | 42 | n. | 12 | 8 | 10 | 13 | 5.9 | 28.4 | 1.8 |
| Wausau | 1,247 | 4 | .... | 28.62 | 30.02 | ..... | 19.6 | ..... | 53 | 2 | 30 | −11 | 5 | 10 | 37 | .... | .... | .... | 2.27 | ..... | 16 | ..... | nw. | .... | .... | .... | 14 | 5 | 12 | .... | 28.2 | 2.0 |
| Charles City | 1,015 | 10 | 49 | 28.93 | 30.05 | .00 | 24.1 | −4.3 | 66 | 2 | 34 | −14 | 19 | 14 | 37 | 21 | 18 | 78 | 2.66 | +0.7 | 9 | 6,798 | nw. | 27 | n. | 3 | 10 | 7 | 14 | 5.6 | 21.7 | 0.0 |
| Davenport | 606 | 71 | 79 | 29.36 | 30.05 | +.02 | 31.6 | −4.5 | 67 | 2 | 41 | −10 | 19 | 22 | 39 | 27 | 22 | 71 | 5.05 | +2.8 | 10 | 6,799 | nw. | 42 | ne. | 11 | 11 | 8 | 12 | 5.7 | 24.8 | T. |
| Des Moines | 861 | 84 | 97 | 29.10 | 30.04 | .00 | 31.5 | −4.4 | 75 | 2 | 41 | −10 | 19 | 22 | 42 | 27 | 22 | 70 | 4.34 | +2.7 | 9 | 7,159 | n. | 32 | sw. | 17 | 7 | 15 | 9 | 5.8 | 25.3 | 0.0 |
| Dubuque | 698 | 81 | 96 | 29.28 | 30.06 | +.02 | 27.6 | −6.4 | 66 | 2 | 36 | −7 | 19 | 19 | 37 | 24 | 19 | 71 | 2.93 | +0.7 | 11 | 6,538 | nw. | 28 | n. | 18 | 9 | 5 | 17 | 6.4 | 20.8 | 0.6 |
| Keokuk | 614 | 64 | 78 | 29.37 | 30.06 | +.03 | 36.0 | −2.9 | 71 | 2 | 46 | −4 | 19 | 25 | 42 | 30 | 24 | 65 | 3.54 | +1.2 | 10 | 7,515 | nw. | 37 | w. | 4 | 12 | 7 | 12 | 5.3 | 6.3 | 0.0 |
| Cairo | 358 | 87 | 93 | 29.70 | 30.09 | +.05 | 44.7 | −2.5 | 70 | 22 | 54 | 9 | 19 | 35 | 45 | 38 | 31 | 63 | 5.00 | +1.0 | 9 | 9,571 | s. | 48 | sw. | 12 | 7 | 13 | 11 | 5.9 | T. | 0.0 |
| Peoria | 609 | 11 | 45 | 29.38 | 30.06 | +.03 | 31.2 | −2.8 | 70 | 2 | 44 | −2 | 19 | 24 | 38 | 30 | 26 | 77 | 4.08 | +1.1 | 12 | 6,939 | nw. | 33 | ne. | 11 | 17 | 1 | 13 | 4.9 | 3.7 | 0.0 |
| Springfield, Ill | 644 | 10 | 91 | 29.35 | 30.04 | +.01 | 37.4 | −2.8 | 74 | 2 | 48 | 2 | 19 | 27 | 44 | 32 | 28 | 75 | 5.23 | +2.2 | 9 | 8,197 | s. | 30 | sw. | 12 | 13 | 6 | 12 | 4.9 | 1.3 | 0.0 |
| Hannibal | 534 | 74 | 109 | 29.46 | 30.05 | +.03 | 37.8 | −3.2 | 71 | 2 | 48 | 0 | 19 | 28 | 40 | .... | .... | .... | 4.24 | +1.5 | 11 | 8,689 | nw. | 40 | sw. | 3 | 14 | 5 | 12 | 5.0 | 1.2 | 0.0 |
| St. Louis | 567 | 265 | 303 | 29.43 | 30.05 | +.02 | 41.4 | −2.4 | 77 | 2 | 52 | 4 | 19 | 31 | 48 | 35 | 29 | 65 | 4.26 | +0.8 | 11 | 11,944 | s. | 64 | sw. | 11 | 12 | 9 | 10 | 5.0 | 0.1 | 0.0 |
| ***Missouri Valley.*** | | | | | | | **34.4** | **−2.3** | | | | | | | | | | **68** | **2.15** | **+0.2** | | | | | | | | | | **5.4** | | |
| Columbia, Mo | 781 | 11 | 84 | 29.19 | 30.05 | +.02 | 39.5 | −1.9 | 73 | 2 | 51 | 2 | 19 | 28 | 41 | .... | .... | .... | 3.61 | +0.6 | 10 | 8,270 | s. | 35 | nw. | 15 | 15 | 2 | 14 | 5.1 | 0.8 | 0.0 |
| Kansas City | 963 | 161 | 181 | 28.98 | 30.04 | +.02 | 39.4 | −1.4 | 78 | 2 | 50 | 0 | 18 | 28 | 34 | 33 | 26 | 63 | 3.35 | +0.5 | 11 | 10,939 | nw. | 49 | nw. | 15 | 13 | 7 | 11 | 5.1 | 2.7 | 0.0 |
| St. Joseph | 967 | 11 | 49 | 28.97 | 30.03 | ..... | 37.4 | ..... | 76 | 2 | 48 | −2 | 18 | 26 | 39 | 31 | 25 | 67 | 2.63 | ..... | 11 | 8,528 | nw. | 39 | w. | 3 | 17 | 3 | 11 | 4.7 | 5.0 | 0.0 |
| Springfield, Mo | 1,324 | 98 | 104 | 28.62 | 30.05 | +.03 | 41.6 | −1.9 | 73 | 2 | 53 | 2 | 19 | 30 | 38 | 35 | 29 | 66 | 2.40 | −1.7 | 6 | 10,168 | se. | 46 | w. | 12 | 14 | 5 | 12 | 4.9 | 0.1 | 0.0 |
| Iola | 984 | 11 | 50 | 28.98 | 30.05 | +.04 | 41.7 | −0.7 | 78 | 2 | 54 | 3 | 19 | 30 | 38 | .... | .... | .... | 3.69 | +1.3 | 7 | 7,602 | s. | 31 | n. | 15 | 10 | 9 | 12 | 5.6 | 1.4 | 0.0 |
| Topeka | 987 | 92 | 107 | ..... | ..... | ..... | 39.4 | −1.5 | 80 | 2 | 52 | −2 | 18 | 27 | 42 | .... | .... | .... | 2.19 | −0.1 | 10 | 10,653 | n. | 46 | w. | 3 | 14 | 4 | 13 | 4.8 | 3.3 | 0.0 |
| Drexel | 1,299 | 10 | 54 | 28.61 | 30.04 | ..... | 30.8 | ..... | 75 | 1 | 41 | −9 | 19 | 20 | 47 | .... | .... | .... | 4.70 | ..... | 8 | 10,001 | n. | 37 | s. | 19 | 6 | 15 | 10 | 6.1 | 28.0 | 0.0 |
| Lincoln | 1,189 | 11 | 84 | 28.75 | 30.06 | +.04 | 33.8 | −2.2 | 78 | 1 | 44 | −7 | 18 | 23 | 44 | 29 | 23 | 72 | 2.26 | +0.9 | 7 | 9,983 | n. | 46 | n. | 17 | 11 | 9 | 11 | 5.6 | 16.4 | 0.0 |
| Omaha | 1,105 | 115 | 122 | 28.84 | 30.06 | +.02 | 32.7 | −4.3 | 78 | 1 | 43 | −8 | 18 | 22 | 47 | 28 | 22 | 71 | 3.95 | +2.6 | 7 | 8,103 | nw. | 48 | nw. | 17 | 9 | 14 | 8 | 5.3 | 28.8 | 0.0 |
| Valentine | 2,598 | 47 | 54 | 27.26 | 30.06 | +.03 | 29.9 | −2.4 | 66 | 1 | 43 | −10 | 18 | 17 | 50 | 25 | 18 | 65 | 0.69 | −0.5 | 9 | 8,143 | nw. | 39 | ne. | 17 | 10 | 13 | 8 | 5.2 | 10.8 | 0.0 |
| Sioux City | 1,135 | 94 | 164 | 28.82 | 30.08 | +.03 | 29.2 | −3.5 | 74 | 1 | 39 | −9 | 18 | 19 | 46 | 25 | 18 | 68 | 1.74 | +0.5 | 7 | 10,353 | n. | 43 | n. | 17 | 7 | 14 | 10 | 6.2 | 16.3 | 0.0 |
| Huron | 1,306 | 59 | 74 | 28.66 | 30.11 | +.05 | 26.6 | −2.3 | 65 | 1 | 38 | −13 | 18 | 15 | 45 | 22 | 17 | 73 | 0.25 | −0.7 | 6 | 8,773 | nw. | 42 | n. | 17 | 13 | 10 | 8 | 4.5 | 2.5 | 0.0 |
| Pierre | 1,572 | 70 | 75 | 28.36 | 30.08 | +.03 | 29.4 | −2.1 | 68 | 1 | 41 | −11 | 18 | 18 | 47 | 25 | 19 | 70 | 0.68 | −0.6 | 7 | 7,921 | nw. | 46 | n. | 17 | 7 | 8 | 16 | 6.4 | 6.4 | 0.0 |
| Yankton | 1,233 | 49 | 57 | 28.71 | 30.08 | +.03 | 29.9 | −3.2 | 73 | 1 | 41 | −8 | 18 | 19 | 45 | .... | .... | .... | 0.95 | −0.2 | 6 | 7,484 | nw. | 32 | nw. | 17 | 7 | 8 | 16 | 6.4 | 8.6 | 0.0 |

TABLE 1.—*Climatological data for Weather Bureau stations, March, 1923*—Continued.

| Districts and stations. | Elevation of instruments: Barometer above sea level. | Elevation of instruments: Thermometer above ground. | Elevation of instruments: Anemometer above ground. | Pressure: Station, reduced to mean of 24 hours. | Pressure: Sea level, reduced to mean of 24 hours. | Pressure: Departure from normal. | Temperature of the air: Mean max. + mean min. ÷ 2. | Temperature of the air: Departure from normal. | Temperature of the air: Maximum. | Temperature of the air: Date. | Temperature of the air: Mean maximum. | Temperature of the air: Minimum. | Temperature of the air: Date. | Temperature of the air: Mean minimum. | Temperature of the air: Greatest daily range. | Mean wet thermometer. | Mean temperature of the dew point. | Mean relative humidity. | Precipitation: Total. | Precipitation: Departure from normal. | Precipitation: Days with .01 inch, or more. | Wind: Total movement. | Wind: Prevailing direction. | Wind: Maximum velocity: Miles per hour. | Wind: Maximum velocity: Direction. | Wind: Maximum velocity: Date. | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness, tenths. | Total snowfall. | Snow, sleet, and ice on ground at end of month. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ft. | Ft. | Ft. | In. | In. | In. | °F. | °F. | °F. | | °F. | °F. | | °F. | °F. | °F. | °F. | % | In. | In. | | Miles. | | | | | | | | 0–10 | In. | In. |
| ***Northern Slope.*** | | | | | | | **30.0** | **−1.2** | | | | | | | | | | **64** | **0.77** | **−0.3** | | | | | | | | | | **5.5** | | |
| Billings | 3,140 | 5 | ... | ... | ... | ... | 34.4 | ... | 72 | 31 | 47 | −9 | 4 | 22 | 50 | ... | ... | ... | 0.75 | ... | 7 | ... | nw. | ... | ... | ... | 6 | 9 | 16 | ... | 10.0 | 0.0 |
| Havre | 2,505 | 11 | 44 | 27.33 | 30.03 | +.03 | 30.6 | +3.5 | 65 | 28 | 42 | 0 | 17 | 20 | 48 | 27 | 21 | 71 | 0.11 | −0.4 | 4 | 7,175 | sw. | 39 | w. | 19 | 11 | 9 | 11 | 5.4 | 1.1 | 0.0 |
| Helena | 4,110 | 87 | 112 | 25.76 | 30.04 | +.03 | 33.1 | +0.7 | 65 | 31 | 43 | 2 | 18 | 24 | 38 | 27 | 18 | 56 | 0.37 | −0.4 | 5 | 7,555 | sw. | 38 | w. | 11 | 3 | 13 | 15 | 6.5 | 7.7 | 0.0 |
| Kalispell | 2,973 | 48 | 56 | 26.92 | 30.04 | +.05 | 32.6 | −0.4 | 64 | 31 | 42 | 7 | 4 | 24 | 33 | 28 | 21 | 64 | 0.42 | −0.7 | 7 | 4,291 | nw. | 36 | w. | 19 | 8 | 12 | 11 | 5.8 | 2.6 | 0.0 |
| Miles City | 2,371 | 48 | 55 | 27.47 | 30.09 | +.07 | 32.0 | +3.4 | 69 | 1 | 44 | 3 | 18 | 21 | 42 | 27 | 19 | 60 | 0.21 | −0.6 | 6 | 5,942 | n. | 36 | w. | 19 | 5 | 13 | 13 | 6.2 | 0.4 | 0.0 |
| Rapid City | 3,259 | 50 | 58 | 26.57 | 30.09 | +.08 | 29.0 | −2.6 | 71 | 1 | 41 | −13 | 18 | 17 | 54 | 25 | 18 | 62 | 1.07 | 0.0 | 7 | 6,558 | n. | 37 | n. | 17 | 10 | 9 | 12 | 5.8 | 11.5 | 0.0 |
| Cheyenne | 6,088 | 84 | 101 | 23.90 | 30.04 | +.08 | 28.2 | −4.9 | 62 | 1 | 38 | −3 | 18 | 18 | 37 | 23 | 15 | 63 | 1.49 | +0.5 | 9 | 13,515 | w. | 64 | w. | 19 | 14 | 8 | 9 | 4.7 | 15.6 | T. |
| Lander | 5,372 | 60 | 68 | 24.58 | 30.06 | +.07 | 28.2 | −3.1 | 62 | 31 | 41 | −13 | 18 | 16 | 46 | 24 | 17 | 66 | 1.88 | +0.3 | 7 | 4,068 | sw. | 50 | w. | 24 | 14 | 10 | 7 | 4.6 | 18.8 | 0.0 |
| Sheridan | 3,790 | 10 | 47 | 26.07 | 30.08 | ... | 28.9 | ... | 67 | 31 | 42 | −17 | 4 | 16 | 44 | 25 | 19 | 68 | 1.89 | ... | 10 | 4,430 | nw. | 30 | sw. | 19 | 12 | 9 | 10 | 5.0 | 18.6 | 0.0 |
| Yellowstone Park | 6,200 | 11 | 48 | 23.80 | 30.12 | +.10 | 21.8 | −4.7 | 58 | 28 | 34 | −14 | 4 | 9 | 40 | 18 | 12 | 68 | 1.00 | −1.2 | 13 | 6,760 | s. | 39 | nw. | 17 | 7 | 11 | 13 | 6.1 | 12.8 | 10.5 |
| North Platte | 2,821 | 11 | 51 | 27.07 | 30.08 | +.08 | 34.2 | −2.4 | 75 | 1 | 48 | −2 | 18 | 20 | 52 | 27 | 19 | 62 | 0.38 | −0.5 | 6 | 6,802 | w | 40 | n. | 17 | 14 | 10 | 7 | 4.5 | 3.5 | 0.0 |
| ***Middle Slope.*** | | | | | | | **39.4** | **−3.4** | | | | | | | | | | **58** | **1.52** | **0.0** | | | | | | | | | | **5.0** | | |
| Denver | 5,292 | 106 | 113 | 24.65 | 30.02 | +.07 | 33.9 | −5.4 | 68 | 31 | 45 | 0 | 18 | 23 | 43 | 27 | 18 | 60 | 2.17 | + .2 | 9 | 6,093 | s. | 45 | nw. | 17 | 15 | 7 | 9 | 4.6 | 25.7 | C.0 |
| Pueblo | 4,685 | 80 | 86 | 25.23 | 29.99 | +.07 | 37.0 | −3.6 | 69 | 20 | 52 | 6 | 18 | 22 | 53 | 29 | 19 | 55 | 0.67 | −0.2 | 6 | 6,551 | nw. | 41 | w. | 16 | 7 | 19 | 5 | 5.5 | 6.9 | 0.0 |
| Concordia | 1,392 | 50 | 58 | 28.53 | 30. 4 | +.03 | 37.9 | −2.8 | 76 | 2 | 50 | −2 | 18 | 26 | 51 | 31 | 23 | 64 | 1.32 | −0.2 | 8 | 8,508 | s. | 42 | n. | 17 | 7 | 15 | 9 | 5.5 | 4.6 | 0.0 |
| Dodge City | 2,509 | 11 | 51 | 27.40 | 30.06 | +.09 | 40.0 | −2.8 | 78 | 1 | 55 | 2 | 18 | 25 | 64 | 31 | 21 | 56 | 0.71 | −0.2 | 8 | 9,616 | nw. | 49 | ne. | 17 | 14 | 8 | 9 | 4.3 | 3.7 | 0.0 |
| Wichita | 1,358 | 139 | 158 | 28.55 | 30.01 | +.02 | 41.6 | −2.5 | 74 | 2 | 54 | 2 | 18 | 29 | 41 | 34 | 24 | 55 | 1.70 | −0.6 | 6 | 12,415 | s. | 50 | sw. | 24 | 11 | 10 | 10 | 5.1 | 0.7 | 0.0 |
| Broken Arrow | 765 | 11 | 52 | 29.22 | 30.05 | ... | 45.8 | ... | 77 | 2 | 57 | 9 | 19 | 34 | 37 | ... | ... | ... | 4.22 | ... | 7 | 12,932 | s. | 49 | nw. | 15 | 8 | 12 | 11 | 5.7 | T. | 0.0 |
| Muskogee | 652 | 4 | ... | ... | ... | ... | 47.8 | ... | 76 | 2 | 59 | 10 | 19 | 36 | 37 | ... | ... | ... | 4.82 | ... | 6 | ... | nw. | ... | ... | ... | 10 | 12 | 9 | ... | T. | 0.0 |
| Oklahoma City | 1,214 | 10 | 47 | 28.75 | 30.05 | +.07 | 46.2 | −3.0 | 80 | 2 | 58 | 9 | 18 | 34 | 34 | 38 | 29 | 59 | 2.58 | +0.2 | 5 | 11,200 | s. | 42 | n. | 15 | 10 | 12 | 9 | 5.0 | 0.1 | 0.0 |
| ***Southern Slope.*** | | | | | | | **49.7** | **−3.5** | | | | | | | | | | **54** | **2.00** | **+1.0** | | | | | | | | | | **4.5** | | |
| Abilene | 1,738 | 10 | 52 | 28.22 | 30.05 | +.09 | 51.2 | −3.7 | 79 | 21 | 63 | 14 | 19 | 39 | 39 | 41 | 31 | 56 | 2.33 | +1.0 | 7 | 9,456 | s. | 48 | w. | 11 | 14 | 8 | 9 | 4.5 | 0.0 | 0.0 |
| Amarillo | 3,676 | 10 | 49 | 26.23 | 30.00 | +.05 | 42.8 | −2.2 | 72 | 2 | 56 | 7 | 18 | 30 | 53 | 35 | 27 | 60 | 2.97 | +2.3 | 7 | 8,763 | sw. | 46 | n. | 17 | 17 | 8 | 6 | 4.2 | 4.4 | 0.0 |
| Del Rio | 944 | 64 | 71 | 29.05 | 30.01 | +.09 | 57.9 | −3.8 | 80 | 21 | 68 | 28 | 20 | 48 | 39 | ... | ... | ... | 2.47 | +1.3 | 6 | 8,033 | se. | 54 | w. | 11 | 15 | 5 | 11 | 4.7 | 0.0 | 0.0 |
| Roswell | 3,566 | 75 | 85 | 26.34 | 29.98 | +.08 | 47.0 | −4.3 | 75 | 20 | 61 | 16 | 19 | 33 | 47 | 37 | 22 | 47 | 0.24 | −0.4 | 6 | 7,855 | s. | 46 | ne. | 17 | 12 | 9 | 10 | 4.5 | 0.1 | 0.0 |
| ***Southern Plateau.*** | | | | | | | **48.2** | **−2.7** | | | | | | | | | | **47** | **0.55** | **+0.1** | | | | | | | | | | **3.1** | | |
| El Paso | 3,762 | 110 | 133 | 26.17 | 29.96 | +.08 | 51.2 | −4. | 76 | 25 | 63 | 24 | 19 | 39 | 40 | 40 | 23 | 40 | 0.33 | 0.0 | 5 | 9,881 | w. | 58 | sw. | 14 | 18 | 8 | 5 | 3.3 | 0.0 | 0.0 |
| Santa Fe | 7,013 | 38 | 53 | 23.16 | 29.97 | +.08 | 34.6 | −5.1 | 57 | 25 | 45 | 6 | 22 | 24 | 34 | 29 | 22 | 63 | 1.28 | +0.6 | 8 | 5,260 | n. | 35 | sw. | 17 | 10 | 8 | 13 | 5.7 | 17.7 | 0.0 |
| Flagstaff | 6,908 | 10 | 59 | 23.28 | 29.94 | +.03 | 33.2 | −2.7 | 58 | 24 | 46 | 4 | 6 | 21 | 41 | 27 | ... | 64 | 1.59 | ... | 6 | 7,324 | w. | 43 | w. | 15 | 18 | 10 | 3 | ... | 15.5 | T. |
| Phoenix | 1,108 | 11 | 81 | 28.81 | 29.98 | +.06 | 58.9 | −1.6 | 84 | 25 | 73 | 35 | 16 | 45 | 42 | 46 | 31 | 43 | 1.08 | +0.6 | 5 | 4,605 | e. | 40 | nw. | 14 | 21 | 4 | 6 | 2.9 | 0.0 | 0.0 |
| Yuma | 141 | 9 | 54 | 29.84 | 29.99 | +.05 | 62.0 | −2.1 | 89 | 25 | 77 | 35 | 5 | 47 | 42 | 47 | 27 | 33 | 0.06 | −0.3 | 2 | 4,839 | n. | 40 | nw. | 14 | 23 | 5 | 3 | 1.9 | 0.0 | 0.0 |
| Independence | 3,957 | 9 | 41 | 26.02 | 30.08 | +.14 | 49.4 | −0.2 | 72 | 30 | 64 | 20 | 5 | 34 | 38 | 37 | 23 | 39 | 0.00 | −0.5 | 0 | 7,457 | nw. | 37 | nw. | 14 | 26 | 4 | 1 | 1.9 | 0.0 | 0.0 |
| ***Middle Plateau.*** | | | | | | | **37.7** | **−3.4** | | | | | | | | | | **51** | **0.80** | **−0.4** | | | | | | | | | | **4.4** | | |
| Reno | 4,532 | 74 | 81 | 25,54 | 30.14 | +.16 | 41.1 | +0.1 | 69 | 29 | 55 | 13 | 4 | 27 | 40 | 33 | 20 | 48 | 0.29 | −0.9 | 4 | 4,755 | w. | 34 | w. | 13 | 17 | 9 | 5 | 3.3 | 3.6 | 0.0 |
| Tonopah | 6,090 | 12 | 20 | 24.06 | 30.05 | ... | 38.2 | ... | 62 | 30 | 49 | 9 | 4 | 28 | 28 | 29 | 13 | 39 | 0.06 | −1.3 | 2 | 8,576 | nw. | 46 | nw. | 20 | 17 | 8 | 6 | 3.8 | 0.4 | 0.0 |
| Winnemucca | 4,344 | 18 | 56 | 25.69 | 30.15 | +.14 | 37.5 | −2.5 | 71 | 30 | 52 | 10 | 4 | 23 | 44 | 30 | 18 | 50 | 0.05 | −0.9 | 2 | 6,387 | sw. | 41 | nw. | 20 | 15 | 8 | 8 | 4.4 | 0.6 | 0.0 |
| Modena | 5,479 | 10 | 43 | 24.61 | 30.04 | +.08 | 34.8 | −4.4 | 65 | 30 | 49 | −7 | 5 | 20 | 45 | 27 | 17 | 54 | 0.90 | −0.4 | 3 | 8,447 | w. | 47 | n. | 14 | 15 | 11 | 5 | 4.0 | 7.9 | 0.0 |
| Salt Lake City | 4,360 | 163 | 203 | 25.65 | 30.09 | +.11 | 37.0 | −4.7 | 66 | 31 | 45 | 13 | 4 | 29 | 25 | 31 | 22 | 56 | 1.67 | −0.3 | 9 | 5,919 | nw. | 42 | nw. | 17 | 11 | 8 | 12 | 5.5 | 14.6 | 0.0 |
| Grand Junction | 4,602 | 60 | 68 | 25.36 | 29.98 | +.04 | 38.0 | −5.5 | 67 | 30 | 50 | 10 | 18 | 26 | 33 | 31 | 22 | 57 | 1.80 | +1.1 | 7 | 4,545 | se. | 32 | nw. | 11 | 11 | 9 | 11 | 5.1 | 14.1 | 0.0 |
| ***Northern Plateau.*** | | | | | | | **40.1** | **−0.3** | | | | | | | | | | **59** | **0.65** | **−0.9** | | | | | | | | | | **5.5** | | |
| Baker | 3,471 | 48 | 53 | 26.52 | 30.17 | +.14 | 36.1 | +0.6 | 70 | 30 | 46 | 11 | 4 | 26 | 39 | 31 | 23 | 64 | 0.36 | −1.1 | 7 | 5,002 | se. | 33 | sw. | 11 | 11 | 11 | 9 | 4.9 | 3.3 | 0.0 |
| Boise | 2,739 | 78 | 86 | 27.26 | 30.17 | +.14 | 40.6 | −2.1 | 74 | 30 | 51 | 17 | 4 | 30 | 36 | 33 | 22 | 49 | 0.24 | −1.2 | 5 | 4,866 | nw. | 36 | n. | 16 | 11 | 11 | 9 | 5.0 | 0.1 | 0.0 |
| Lewiston | 757 | 40 | 48 | 29.32 | 30.15 | +.12 | 45.0 | +1.0 | 80 | 30 | 56 | 25 | 4 | 34 | 42 | ... | ... | ... | 0.98 | −0.3 | 10 | 4,002 | e. | 35 | w. | 16 | 8 | 7 | 16 | 6.3 | 0.3 | 0.0 |
| Pocatello | 4,477 | 60 | 68 | 25.48 | 30.10 | +.09 | 33.0 | −3.9 | 63 | 30 | 43 | 4 | 4 | 23 | 31 | 28 | 21 | 64 | 1.33 | −0.4 | 11 | 8,109 | se. | 40 | sw. | 16 | 10 | 10 | 11 | 5.2 | 10.0 | 0.0 |
| Spokane | 1,929 | 101 | 110 | 28.02 | 30.12 | +.11 | 39.5 | −0.2 | 70 | 30 | 49 | 18 | 3 | 30 | 35 | 34 | 27 | 64 | 0.54 | −1.0 | 10 | 5,166 | sw. | 40 | sw. | 19 | 8 | 9 | 14 | 5.8 | 3.1 | 0.0 |
| Walla Walla | 991 | 57 | 65 | 29.06 | 30.15 | +.13 | 46.6 | +2.6 | 78 | 29 | 56 | 26 | 3 | 38 | 34 | 39 | 30 | 55 | 0.47 | −1.4 | 4 | 5,185 | sw. | 40 | w. | 16 | 10 | 7 | 14 | 5.6 | T. | 0.0 |
| ***North Pacific Coast Region.*** | | | | | | | **44.9** | **−0.1** | | | | | | | | | | **79** | **2.44** | **−2.1** | | | | | | | | | | **6.2** | | |
| North Head | 211 | 11 | 56 | 29.99 | 30.22 | +.21 | 44.3 | −0.6 | 68 | 28 | 49 | 33 | 3 | 40 | 18 | 42 | 40 | 84 | 2.94 | −2.3 | 18 | 12,455 | nw. | 58 | s. | 10 | 8 | 6 | 17 | 6.4 | T. | 0.0 |
| Port Angeles | 29 | 8 | 53 | 30.17 | 30.20 | ... | 42.0 | ... | 60 | 29 | 49 | 27 | 3 | 35 | 23 | ... | ... | ... | 1.90 | −0.3 | 12 | 5,400 | s. | 46 | w. | 10 | 13 | 8 | 10 | 5.2 | 0.3 | 0.0 |
| Seattle | 125 | 215 | 250 | 30.07 | 30.12 | +.21 | 44.0 | −0.2 | 70 | 29 | 50 | 29 | 3 | 38 | 26 | 40 | 36 | 74 | 1.37 | −1.5 | 15 | 7,726 | s. | 50 | sw. | 10 | 7 | 8 | 16 | 6.7 | 0.7 | 0.0 |
| Tacoma | 213 | 113 | 120 | 29.98 | 30.21 | +.21 | 43.6 | −0.6 | 76 | 29 | 51 | 26 | 3 | 36 | 35 | ... | ... | ... | 2.07 | −1.9 | 15 | 5,732 | sw. | 36 | sw. | 16 | 4 | 15 | 12 | 6.6 | T. | 0.0 |
| Tatoosh Island | 86 | 9 | 57 | 30.07 | 30.18 | +.22 | 43.2 | +0.3 | 61 | 29 | 47 | 34 | 1 | 39 | 17 | 42 | 41 | 91 | 5.66 | −2.9 | 18 | 13,248 | w. | 56 | s. | 10 | 5 | 10 | 16 | 7.0 | 0.0 | 0.0 |
| Yakima | 1,071 | 4 | ... | ... | ... | ... | 42.9 | ... | 80 | 30 | 58 | 20 | 3 | 28 | 48 | ... | ... | ... | 0.19 | ... | 3 | ... | nw. | ... | ... | ... | 17 | 10 | 4 | ... | 0.0 | 0.0 |
| Medford | 1,425 | 4 | ... | ... | ... | ... | 45.9 | ... | 82 | 29 | 60 | 18 | 3 | 31 | 50 | ... | ... | ... | 0.41 | ... | 5 | ... | nw. | ... | ... | ... | 12 | 3 | 16 | ... | 0.5 | 0.0 |
| Portland, Oreg. | 153 | 68 | 106 | 30.06 | 30.22 | +.20 | 47.2 | +0.3 | 82 | 29 | 56 | 27 | 3 | 39 | 33 | 43 | 38 | 74 | 1.83 | −3.4 | 18 | 4,655 | nw. | 28 | sw. | 16 | 8 | 6 | 17 | 6.4 | T. | 0.0 |
| Roseburg | 510 | 9 | 57 | 29.71 | 30.27 | +.23 | 47.2 | +0.1 | 85 | 28 | 58 | 22 | 4 | 36 | 45 | 42 | 36 | 71 | 1.32 | −2.7 | 13 | 2,291 | n. | 15 | sw. | 12 | 6 | 16 | 9 | 5.3 | T. | 0.0 |
| ***Middle Pacific Coast Region.*** | | | | | | | **53.5** | **+1.3** | | | | | | | | | | **59** | **0.33** | **−3.7** | | | | | | | | | | **3.3** | | |
| Eureka | 62 | 73 | 89 | 30.18 | 30.26 | +.20 | 47.4 | −0.6 | 74 | 28 | 54 | 31 | 4 | 41 | 30 | 44 | 40 | 80 | 0.80 | −6.2 | 10 | 6,677 | n. | 46 | n. | 2 | 11 | 10 | 10 | 5.0 | 0.0 | 0.0 |
| Point Reyes | 490 | 7 | 18 | 29.56 | 30.08 | ... | 50.2 | +0.6 | 73 | 26 | 55 | 41 | 24 | 45 | 25 | ... | ... | ... | 0.05 | ... | 2 | 18,055 | nw. | 76 | nw. | 8 | 17 | 7 | 7 | 4.0 | 0.0 | 0.0 |
| Red Bluff | 332 | 50 | 56 | 29.76 | 30.12 | +.08 | 56.4 | +2.8 | 87 | 27 | 69 | 36 | 7 | 44 | 38 | 45 | 30 | 41 | 0.09 | −3.7 | 1 | 5,823 | nw. | 36 | n. | 3 | 25 | 6 | 0 | 1.8 | 0.0 | 0.0 |
| Sacramento | 69 | 106 | 117 | 30.03 | 30.10 | +.07 | 56.4 | +2.1 | 85 | 27 | 68 | 35 | 4 | 44 | 35 | 47 | 36 | 52 | 0.43 | −2.6 | 2 | 6,746 | nw. | 39 | nw. | 3 | 22 | 6 | 3 | 2.5 | T. | 0.0 |
| San Francisco | 155 | 208 | 243 | 29.95 | 30.12 | +.06 | 56.8 | +2.6 | 81 | 27 | 65 | 44 | 5 | 49 | 31 | 48 | 41 | 63 | 0.03 | −3.1 | 2 | 6,283 | w. | 35 | n. | 14 | 23 | 5 | 3 | 2.8 | 0.0 | 0.0 |
| San Jose | 141 | 12 | 110 | 29.96 | 30.11 | ... | 54.0 | +0.3 | 85 | 27 | 68 | 32 | 5 | 40 | 45 | ... | ... | ... | 0.31 | −2.7 | 1 | 4,780 | nw. | 24 | n. | 14 | 18 | 7 | 6 | 3.5 | 0.0 | 0.0 |
| ***South Pacific Coast Region.*** | | | | | | | **58.0** | **+2.4** | | | | | | | | | | **58** | **0.28** | **−2.4** | | | | | | | | | | **2.6** | | |
| Fresno | 327 | 89 | 98 | 29.73 | 30.09 | +.08 | 56.8 | +1.9 | 85 | 28 | 70 | 34 | 4 | 44 | 35 | 47 | 36 | 52 | 0.06 | −1.7 | 1 | 4,419 | nw. | 42 | nw. | 20 | 23 | 1 | 7 | 2.8 | 0.0 | 0.0 |
| Los Angeles | 338 | 159 | 191 | 29.68 | 30.05 | +.03 | 61.0 | +4.1 | 85 | 26 | 71 | 41 | 5 | 51 | 30 | 49 | 38 | 51 | 0.32 | −2.7 | 2 | 4,484 | e. | 28 | sw. | 9 | 22 | 4 | 5 | 2.3 | 0.0 | 0.0 |
| San Diego | 87 | 62 | 70 | 29.94 | 30.03 | +.01 | 58.4 | +1.7 | 82 | 26 | 67 | 40 | 5 | 49 | 32 | 51 | 46 | 69 | 0.34 | −1.4 | 4 | 4,450 | nw. | 26 | w. | 10 | 22 | 2 | 7 | 2.9 | 0.0 | 0.0 |
| San Luis Obispo | 201 | 32 | 40 | 29.88 | 30.10 | +.04 | 55.8 | +2.0 | 87 | 26 | 70 | 34 | 9 | 41 | 42 | 46 | 38 | 60 | 0.38 | −3.6 | 3 | 3,188 | n. | 24 | ne. | 12 | 24 | 3 | 4 | 2.3 | 0.0 | 0.0 |
| ***West Indies.*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| San Juan, P. R. | 82 | 9 | 54 | 29.98 | 30.11 | ... | 74.2 | −1.2 | 86 | 1 | 79 | 66 | 20 | 69 | 18 | ... | ... | ... | 1.70 | −1.4 | 14 | 13,461 | e. | 46 | e. | 18 | 10 | 20 | 1 | 4.5 | 0.0 | 0.0 |
| ***Panama Canal.*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Balboa Heights | 118 | 7 | 97 | 29.73 | 29.85 | −.01 | 80.8 | −0.4 | 91 | 21 | 89 | 68 | 3 | 72 | 20 | 71 | 68 | 74 | T. | −0.7 | 0 | 9,606 | n. | 30 | n. | 15 | 2 | 28 | 1 | 5.1 | 0.0 | 0.0 |
| Colon | 36 | 7 | 97 | 29.84 | 29.88 | −.01 | 81.0 | +0.6 | 87 | 17 | 86 | 74 | 23 | 77 | 12 | 74 | 72 | 79 | 0.36 | −1.2 | 9 | 13,282 | n. | 29 | n. | 10 | 2 | 27 | 2 | 5.5 | 0.0 | 0.0 |
| ***Alaska.*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Juneau | 80 | 11 | 54 | 29.9 | 29.99 | ... | 32.8 | ... | 48 | 31 | 38 | 14 | 13 | 28 | 18 | 3 | 26 | 80 | 7.95 | ... | 22 | 5,35[illegible] | s. | 30 | e. | 12 | 4 | 7 | 20 | 8.2 | 39.7 | T. |

TABLE 2.—*Data furnished by the Canadian Meteorological Service, March, 1923.*

| Stations. | Altitude above mean sea level, Jan. 1, 1919. | Pressure. | | | Temperature of the air. | | | | | | Precipitation. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Station reduced to mean of 24 hours. | Sea level reduced to mean of 24 hours. | Departure from normal. | Mean max.+mean min.÷2. | Departure from normal. | Mean maximum. | Mean minimum. | Highest. | Lowest. | Total. | Departure from normal. | Total snowfall. |
| | *Feet.* | *In.* | *In.* | *In.* | ° *F.* | ° *F.* | ° *F.* | ° *F.* | ° *F.* | ° *F.* | *In.* | *In.* | *In.* |
| Sydney, C. B. I | 48 | 29.80 | 29.85 | −.03 | 20.1 | −6.2 | 29.8 | 10.3 | 42 | −10 | 6.58 | +1.65 | 47.0 |
| Halifax, N. S | 88 | 29.78 | 29.89 | −.05 | 23.6 | −5.4 | 33.5 | 13.8 | 45 | −5 | 4.95 | −0.51 | 27.6 |
| Yarmouth, N. S | 65 | 29.84 | 29.91 | −.04 | 26.5 | −4.3 | 34.1 | 18.9 | 46 | 1 | 4.16 | −0.69 | 31.4 |
| Charlottetown, P. E. I | 38 | 29.82 | 29.86 | −.04 | 18.7 | −6.7 | 27.9 | 9.6 | 44 | −10 | 2.85 | −0.36 | 25.0 |
| Chatham, N. B | 28 | 29.77 | 29.81 | −.09 | 15.2 | −7.8 | 21.1 | 3.3 | 43 | −24 | 2.89 | −0.58 | 23.1 |
| Father Point, Que | 20 | 29.88 | 29.91 | +.01 | 11.7 | −8.6 | 19.4 | 4.0 | 41 | −12 | 2.03 | −0.70 | 20.3 |
| Quebec, Que | 296 | 29.61 | 29.95 | −.01 | 15.7 | −5.5 | 23.9 | 7.5 | 46 | −13 | 2.97 | −0.29 | 29.0 |
| Montreal, Que | 187 | 29.74 | 29.96 | −.04 | 18.9 | −4.9 | 26.5 | 11.4 | 47 | −9 | 2.82 | −0.97 | 24.4 |
| Ottawa, Ont | 236 | 29.71 | 29.99 | −.02 | 18.7 | −2.8 | 27.6 | 9.9 | 48 | −12 | 2.43 | −0.29 | 24.1 |
| Kingston, Ont | 285 | 29.66 | 29.99 | −.02 | 22.7 | −2.9 | 30.7 | 14.7 | 46 | −4 | 2.10 | −0.54 | 11.7 |
| Toronto, Ont | 379 | 29.57 | 30.00 | −.02 | 27.1 | −0.2 | 35.5 | 18.6 | 51 | 3 | 3.10 | +0.46 | 20.5 |
| Cochrane, Ont | 930 | | | | 4.1 | | 15.1 | −6.8 | 38 | −24 | 1.00 | | 10.0 |
| White River, Ont | 1,244 | 28.60 | 29.99 | −.04 | 2.1 | −10.1 | 17.8 | −13.5 | 46 | −42 | 2.22 | +0.84 | 22.2 |
| Southampton, Ont | 656 | 29.24 | | | 20.9 | −3.8 | 28.9 | 12.9 | 46 | −9 | 3.61 | +0.96 | 22.7 |
| Parry Sound, Ont | 688 | 29.21 | 29.94 | −.08 | 15.6 | −5.5 | 25.0 | 6.2 | 44 | −19 | 2.86 | +0.63 | 27.4 |
| Port Arthur, Ont | 644 | 29.29 | 30.03 | −.02 | 11.7 | −5.1 | 21.0 | 2.4 | 38 | −16 | 0.83 | −0.14 | 8.3 |
| Winnipeg, Man | 760 | 29.23 | 30.12 | +.03 | 6.5 | −5.8 | 18.3 | −5.3 | 45 | −27 | 1.29 | +0.26 | 12.9 |
| Minnedosa, Man | 1,690 | 28.18 | 30.12 | +.06 | 3.2 | −9.3 | 13.7 | −7.3 | 47 | −40 | 1.61 | +0.96 | 16.1 |
| Le Pas, Man | 860 | | | | 0.4 | | 13.8 | −12.9 | 41 | −36 | 0.30 | | 3.0 |
| Qu'Appelle, Sask | 2,115 | 27.69 | 30.05 | +.01 | 10.6 | −4.3 | 22.7 | −1.5 | 44 | −25 | 1.68 | +0.91 | 16.8 |
| Medicine Hat, Alb | 2,144 | 27.62 | 29.96 | −.04 | 28.2 | +0.7 | 38.1 | 18.4 | 57 | −2 | 0.43 | −0.33 | 4.3 |
| Moose Jaw, Sask | 1,759 | | | | 15.4 | | 24.1 | 6.8 | 46 | −17 | 0.27 | | 2.0 |
| Swift Current, Sask | 2,392 | 27.37 | 30.10 | +.08 | 20.4 | −1.6 | 31.4 | 9.5 | 51 | −15 | 0.55 | −0.26 | 5.5 |
| Banff, Alb | 4,521 | 25.28 | 29.98 | +.04 | 26.5 | +6.3 | 38.9 | 14.1 | 62 | −12 | 0.39 | −1.02 | 3.7 |
| Edmonton, Alb | 2,150 | 27.62 | 29.98 | +.02 | 20.3 | −3.9 | 30.0 | 10.6 | 53 | −11 | 1.68 | +0.96 | 15.8 |
| Prince Albert, Sask | 1,450 | 28.48 | 30.14 | +.06 | 8.4 | −3.6 | 21.2 | −4.3 | 44 | −27 | 0.31 | −0.46 | 3.1 |
| Battleford, Sask | 1,592 | 28.25 | 30.07 | +.01 | 15.4 | +2.3 | 25.8 | 4.9 | 45 | −17 | 0.26 | −0.20 | 2.6 |
| Victoria, B. C | 230 | 29.91 | 30.17 | +.20 | 43.3 | +1.5 | 49.0 | 37.9 | 65 | 31 | 2.81 | −0.31 | T. |
| **Late reports, February, 1923.** | | | | | | | | | | | | | |
| St. Johns, N. F | 125 | 29.50 | 29.65 | −.18 | 12.5 | −9.5 | 18.8 | 6.3 | 32 | −10 | 1.30 | −3.61 | 13.0 |
| Medicine Hat, Alb | 2,144 | 27.84 | 30.21 | +.16 | 15.1 | +3.9 | 26.1 | 4.1 | 55 | −34 | 3.90 | +3.23 | 39.0 |
| Calgary, Alb | 3,428 | 26.51 | 30.26 | +.27 | 17.7 | +4.2 | 30.7 | 4.8 | 63 | −39 | 0.59 | −0.04 | 5.9 |
| Banff, Alb | 4,521 | 25.46 | 30.27 | +.28 | 17.8 | −1.4 | 29.9 | 5.7 | 54 | −43 | 0.23 | −0.69 | 2.3 |
| Edmonton, Alb | 2,150 | 27.80 | 30.21 | +.19 | 13.3 | +5.0 | 24.6 | 2.0 | 59 | −36 | 0.77 | +0.10 | 6.1 |
| Kamloops, B. C | 1,262 | 29.04 | 30.40 | +.44 | 23.3 | −5.0 | 31.3 | 15.3 | 49 | −14 | 0.45 | −0.34 | 4.5 |
| Barkerville, B. C | 4,180 | 25.75 | 30.20 | +.29 | 19.4 | +0.5 | 28.3 | 10.6 | 43 | −34 | 2.82 | −0.24 | 26.0 |

## SEISMOLOGICAL REPORTS FOR MARCH, 1923.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, May 3, 1923.]

TABLE 1.—*Noninstrumental earthquake reports, March, 1923.*

| Day. | Approximate time (Greenwich civil). | Station. | Approximate latitude. | Approximate longitude. | Intensity (Rossi-Forel). | Number of shocks. | Duration. | Sounds. | Remarks. | Observer. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1923. | *H. m.* | CALIFORNIA. | ° ′ | ° ′ | | | *Sec.* | | | |
| 3 | ? | Brawley | 32 59 | 115 40 | ? | 1 | | None | | M. D. Witter. |
| 12 | 6 00 | Los Alamos | 34 45 | 120 15 | 4 | 1 | | do | | H. R. Geve. |
| 28 | 22 13 | Eureka | 40 48 | 124 10 | 3 | 1 | 1 | do | Felt by many | L. B. Cooper. |
| | | ILLINOIS. | | | | | | | | |
| 9 | 2 45 | Greenville | 38 50 | 89 20 | 4 | 1 | 2-3 | None | Felt by several | J. M. Hawley. |
| | | MISSISSIPPI. | | | | | | | | |
| 27 | 8 00 | Wyatte | 34 35 | 89 45 | 4 | 1 | 2 | Rumbling | Felt by several | Dr. W. F. Coleman. |
| | | NEW MEXICO. | | | | | | | | |
| 7 | 5 04 | Columbus | 32 00 | 107 40 | | 2 | 10ca | | Felt by several | W. E. Turner. |
| | | SOUTH CAROLINA. | | | | | | | | |
| 23 | 4 25 | Charleston | 32 45 | 80 00 | ? | | 15-20 | Rumbling | Felt by one | L. Dahlmann. |
| | 4 30 | do | 32 45 | 80 00 | | 1 | | | Felt by two | G. D. Cook. |
| | | Summerville | 33 05 | 80 15 | 2(?) | 1 | | Faint | Felt by many | Mrs. W. Robertson. |
| | | TEXAS. | | | | | | | | |
| 7 | 5 03 | Sierra Blanca | 31 10 | 105 25 | 2 | | 10 | Faint | Felt by several | H. W. Reynolds. |
| | | El Paso | 31 45 | 106 30 | 5 | 2 | 1, 2 | None | Felt by many | R. M. Shaver. |
| | | WASHINGTON. | | | | | | | | |
| 12 | 18 15 | Anacortes | 48 30 | 122 40 | 4 | 1 | 5-6 | None | Felt by many | W. B. Short. |
| | | Marietta | 48 50 | 122 40 | 4 | 1 | 10 | | do | S. B. Mayhew. |
| | 18 20 | Olga | 48 40 | 122 50 | 2 | 1 | 5ca | None | do | C. S. Willis. |

TABLE 2.—*Instrumental seismological reports, March, 1923.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

For significance of symbols and description of stations, see REVIEW for January, 1922.

ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. $A_E$ | Amplitude. $A_N$ | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
| Mar. 2 | | $e_E$ | 17 12 20 | | | | | Nothing definite on N. |
| | | $e_N$ | 17 12 43 | | | | | |
| | | $L1_E$ | 17 31 07 | | | | | |
| | | $L2_E$ | 17 33 01 | 28 | | | | |
| | | $M_E$ | 17 34 45 | 28 | *500 | | | |
| | | $C_E$ | 17 36 .. | | | | | |
| | | $F_E$ | 18 15 .. | | | | | |
| | | $F_N$ | 18 02 .. | | | | | |
| 24 | | $e_E$ | 13 16 32 | | | | | |
| | | $e_N$ | 13 18 32 | | | | | |
| | | $L1_E$ | 13 19 40 | 36 | | | | |
| | | $L2_E$ | 13 22 05 | 27 | | | | |
| | | $L_N$ | 13 19 52 | 36 | | | | |
| | | $M_E$ | 13 27 41 | 15 | *2,300 | | | |
| | | $M_N$ | 13 24 06 | 15 | | *2,000 | | |
| | | $C_E$ | 13 32 .. | 13 | | | | |
| | | $C_N$ | 13 24 35 | | | | | |
| | | F | 14 06 .. | | | | | |

* Trace amplitude.

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. $A_E$ | Amplitude. $A_N$ | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
| Mar. 7 | | P | 5 02 58 | 3 | | | | Local. |
| | | $S_N$ | 5 03 33 | 3 | | | | |
| | | $e_E$ | 5 03 42 | | *100 | | | |
| | | $iL_N$ | 5 03 47 | 3 | | | | |
| | | $M_N$ | 5 03 49 | 3 | | *500 | | |
| | | F | 5 08 .. | | | | | |
| 18 | | P | 20 29 54 | 2 | | | | Local; recorded on the magnetograph. |
| | | $L_N$(?) | 20 30 23 | | | | | |
| | | $M_E$ | 20 30 27 | 4 | *200 | | | |
| | | $M_N$ | 20 30 31 | | | *400 | | |
| | | $F_E$ | 20 35 .. | | | | | |
| | | $F_N$ | 20 38 .. | | | | | |

* Trace amplitude.

CALIFORNIA. *Theosophical University, Point Loma.*

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. $A_E$ | Amplitude. $A_N$ | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
| Mar. 2 | | | | | 100 | 100 | | Tremors during preceding 24 hours. |
| 3 | | | | | 100 | 100 | | |
| 10 | | | | | 150 | 300 | | |
| 11 | | | | | 50 | 50 | | |
| 15 | | | | | 50 | 50 | | |
| 19 | | | | | 50 | 50 | | |
| 20 | | | | | 100 | 100 | | |
| 27 | | | | | 200 | 300 | | |
| 28 | | | | | 100 | 100 | | |
| 30 | | | | | 50 | 50 | | |
| 31 | | | | | 50 | 50 | | |

DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. $A_E$ | Amplitude. $A_N$ | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
| Mar. 1 | | eL | 8 45 .. | | | | | |
| | | F | 9 30 .. | | | | | |
| 2 | | eS | 17 10 04 | | | | | |
| | | eL | 17 28 .. | | | | | |
| | | L | 17 57 .. | 30 | | | | |
| | | L | 18 12 .. | 16 | | | | |
| | | F | 18 45 .. | | | | | |
| 11 | | e | 23 24 .. | | | | | |
| | | F | 23 35 .. | | | | | |
| 15 | | e | 6 08 .. | | | | | Many short-period vibrations. |
| | | e | 6 11 50 | | | | | |
| | | eL | 6 15 20 | | | | | |
| | | L | 6 17 30 | 22 | | | | |
| | | F | 6 30 .. | | | | | |
| 16 | | e | 22 22 46 | | | | | |
| | | S | 22 31 54 | | | | | |
| | | eL | 22 49 20 | | | | | |
| | | L | 23 00 .. | 24 | | | | |
| | | L | 23 22 .. | 20 | | | | |
| | | L | 23 29 .. | 16 | | | | |
| 17 | | F | 0 10 .. | | | | | |
| 24 | | P? | 12 56 12 | | | | | |
| | | S? | 13 05 08 | | | | | |
| | | eL | 13 33 30 | 28 | | | | |
| | | L | 13 44 50 | 20 | | | | |
| | | L | 13 51 .. | 16 | | | | |
| | | F | 14 50 ca | | | | | |

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. $A_E$ | Amplitude. $A_N$ | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
| Mar. 1 | | e | 8 40 05 | 15 | 30 | | | |
| | | $M_E$ | 8 44 26 | 8 | 60 | | | |
| | | $M_N$ | 8 43 36 | 8 | | | 40 | |
| | | $F_E$ | 9 41 .. | | | | | |
| | | $F_N$ | 9 44 .. | | | | | |
| 2 | | $e_N$ | 17 20 42 | 25 | | | | E obscured by overlap; beginning occurred while changing paper. |
| | | $e_N$ | 17 25 32 | 22 | | 45 | | |
| | | $L_N$ | 17 30 10 | 20 | | | | |
| | | $M_N$ | 17 33 20 | 18 | | 32 | | |
| | | $F_N$ | 18 10 .. | | | | | |
| 4 | | *O* | 7 04 10 | | | | 1,650 | E well defined; N indefinite. |
| | | $P_E$ | 7 07 42 | | | | | |
| | | $S_E$ | 7 10 33 | 16 | 33 | | | |
| | | $S_N$ | 7 10 49 | 18 | | | | |
| | | L | 7 11 46 | 12 | | | | |
| | | $M_E$ | 7 12 10 | 12 | 38 | | | |
| | | $M_N$ | 7 16 06 | 11 | | 21 | | |
| | | F | 7 58 .. | | | | | |
| 16 | | e | 22 22 57 | 8 | 18 | | | |
| | | $e_N$ | 22 27 20 | 9 | | | | |
| | | $e_E$ | 22 35 48 | 25 | | | | |
| | | $e_E$ | 22 44 42 | | | | | |
| | | $L_E$ | 22 49 10 | | | | | |
| | | $M_E$ | 22 50 .. | 17 | 50 | | | |
| | | $M_N$ | 22 49 09 | 18 | | 40 | | |
| | | $F_E$ | 23 24 .. | | | | | |
| | | $F_N$ | 23 00 .. | | | | | |
| 24 | | *O* | 12 56 46 | | | | 3,780 | |
| | | P | 13 03 48 | | | | | |
| | | $S_E$ | 13 09 22 | 11 | | | | |
| | | $S_N$ | 13 09 50 | | | | | |
| | | $L_E1$ | 13 13 40 | 11 | | | | |
| | | $L_E2$ | 13 18 10 | | | | | |
| | | $L_E3$ | 13 22 10 | 25 | | | | |
| | | $L_N1$ | 13 15 55 | 40 | | | | |
| | | $L_N2$ | 13 26 10 | 14 | | | | |
| | | $M_E$ | 13 26 50 | 13 | 42 | | | |
| | | $M_N$ | 13 27 17 | 14 | | 32 | | |
| | | F | 14 24 .. | | | | | |

ILLINOIS. *U. S. Weather Bureau, Chicago.*

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. $A_E$ | Amplitude. $A_N$ | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
| Mar. 1 | | P | 8 34 46 | | | | 6,400 | |
| | | S | 8 42 33 | | | | | |
| | | L | 8 51 12 | 20 | | | | |
| | | L | 8 58 .. | 15 | | | | |
| | | L | 9 12 .. | 12 | | | | |
| | | F | 10 40 *ca.* | | | | | |
| 2 | | S? | 17 09 34 | | | | | |
| | | eL | 17 41 30 | | | | | |
| | | L | 17 52 .. | 22 | | | | |
| | | L | 18 07 .. | 15 | | | | |
| | | F | 20 *ca.* .. | | | | | |
| 11 | | S | 23 19? | | | | | Time-marking mechanism out of order. |
| | | L | 23 22? | | | | | |
| | | F | 24 *ca.* | | | | | |
| 13 | | i | 20 07 37 | | | | | |
| | | L | 20 20 40 | | | | | |
| | | L | 20 25 50 | 15 | | | | |
| | | F | 21 *ca.* | | | | | |
| 14 | | P | 21 04 31 | | | | | |
| | | S | 21 13 23 | | | | | |
| | | L | 21 40 .. | 20 | | | | |
| | | L | 21 58 .. | 18 | | | | |
| | | L | 22 10 .. | 15 | | | | |
| | | F | 23 *ca.* | | | | | |
| 15 | | P | 5 51 44 | | | | 7,600 | |
| | | S | 6 01 00 | | | | | |
| | | eL | 6 14 .. | 18 | | | | |
| | | L | 6 23 .. | 15 | | | | |
| | | F | 7 30 *ca.* | | | | | |
| 16 | | P | 22 22 10 | | | | 8,500 | |
| | | S | 22 31 55 | | | | | |
| | | L | 22 39 00 | | | | | |
| | | L | 22 58 .. | 20 | | | | |
| | | L | 23 13 .. | 18 | | | | |
| | | L | 23 28 .. | 15 | | | | |
| 17 | | F | 1 20 *ca.* | | | | | |
| 18 | | P | 20 39 39 | | | | 650 | |
| | | S | 20 40 49 | | | | | |
| | | L | 20 40 55 | 11 | | | | |
| | | F | 20 50 *ca.* | | | | | Micros. |
| 19 | | L | 11 27 .. | 18 | | | | |
| | | F | | | | | | Do. |

ILLINOIS. *U. S. Weather Bureau, Chicago*—Continued.

| 1923. | | H. m. s. | Sec. | μ | μ | Km. |
|---|---|---|---|---|---|---|
| Mar. 24 | e | 12 59 08 | | | | |
| | L | 13 31 .. | 22 | | | |
| | L | 13 50 .. | 18 | | | |
| | L | 14 10 .. | 15 | | | |
| | F | 15 40 *ca.* | | | | |
| 26 | e | 14 58 20 | | | | |
| | L | 15 10 20 | 18 | | | |
| | L | 15 20 .. | 15 | | | |
| | F | 15 45 *ca.* | | | | |

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Mar. 24 | | $e_N$ | 13 38 22 | | | | | |
| | | $e_E$ | 13 40 04 | 24 | | | | |
| | | $e_E$ | 13 46 07 | 23 | | | | |
| | | $L_N$ | 13 45 43 | 26 | | | | |
| | | $M_E$ | 13 47 58 | 19 | *200 | | | |
| | | $M_N$ | 13 46 53 | 26 | | *100 | | |
| | | $F_E$ | 14 01 .. | | | | | |
| | | $F_N$ | 13 59 .. | | | | | |

*Trace amplitude.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Mar. 15 | | i | 6 03 43 | | | | | L waves superimposed by tremors of 2 or 3 sec. period. Felt in Porto Rico, especially near Mayaguez. |
| | | $M_E$ | 6 04 33 | 16 | *3300 | | | |
| | | $M_N$ | 6 04 26 | 17 | | *4500 | | |
| | | $e_E$ | 6 04 59 | 10 | | | | |
| | | $C_N$ | 6 05 10 | 5 | | | | |
| | | $F_E$ | 6 15 .. | | | | | |
| | | $F_N$ | 6 18 .. | | | | | |

*Trace amplitude.

CANAL ZONE. *Panama Canal, Balboa Heights.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Mar. 19 | | $P_E$ | 11 14 44 | | | | 465 *ca.* | Probably northwest. |
| | | $P_N$ | 11 14 40 | | | | | |
| | | $S_E$ | 11 16 34 | | | | | |
| | | $S_N$ | 11 15 30 | | | | | |
| | | $M_E$ | 11 16 25 | | *4500 | | | |
| | | $M_N$ | 11 15 54 | | | *4500 | | |
| | | $F_E$ | 11 30 10 | | | | | |
| | | $F_N$ | 11 32 50 | | | | | |
| 21 | | $P_E$ | 9 10 34 | | | | | Probably southwest. |
| | | $P_N$ | 9 10 34 | | | | 145 *ca.* | |
| | | S | 9 10 50 | | | | | |
| | | $M_E$ | 9 11 00 | | *500 | | | |
| | | $M_N$ | 9 10 52 | | | *800 | | |
| | | $F_E$ | 9 15 00 | | | | | |
| | | $F_N$ | 9 15 30 | | | | | |
| 24 | | $P_E$ | 8 37 36 | | | | 370 *ca.* | Probably northwest. |
| | | $S_E$ | 8 38 16 | | | | | |
| | | $S_N$ | 8 38 14 | | | | | |
| | | $L_E$ | 8 38 50 | | | | | |
| | | $L_N$ | 8 38 46 | | | | | |
| | | $M_E$ | 8 38 53 | | *2000 | | | |
| | | $M_N$ | 8 38 51 | | | *1500 | | |
| | | $F_E$ | 8 44 40 | | | | | |
| | | $F_N$ | 8 45 00 | | | | | |

*Trace amplitude.

VERMONT. *U. S. Weather Bureau, Northfield.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Mar. 1 | | eL | 8 57 .. | | | | | Faint. |
| | | F | 9 15 .. | | | | | |
| 2 | | $eL_E$ | 17 58 .. | | | | | |
| | | $F_E$ | 18 05 .. | | | | | |
| 24 | | eL | 13 39 .. | | | | | |
| | | L | 13 43 .. | 16 | | | | |
| | | F | 14 *ca.* .. | | | | | |

CANADA. *Dominion Observatory, Ottawa.*

INSTRUMENTS—FIXED CONSTANTS.

| Instrument. | Symbol. | Registration. | Damping. | Paper speed. | Mass. |
|---|---|---|---|---|---|
| Bosch | I | Photographic | Air | 15 mm. per min. | 200 g. |
| Do | II | do | Magnetic | do | Do. |
| Milne-Shaw | 17 | do | do | 8 mm. per min. | 1 lb. |
| Do | 23 | do | do | do | Do. |
| Deformation | D | do | Air | 17 mm. per hour | 20 g. ca. |
| Spindler-Hoyer | W | Smoked sheet | do | 15 mm. per min. | 80 kgm. |

CANADA. *Dominion Observatory, Ottawa.*

INSTRUMENTS—DETERMINED CONSTANTS.

| Instrument. | To— | r. | v. | ε. | Comp. | l. | Determined. |
|---|---|---|---|---|---|---|---|
| I | 5.5 | | 120 | 2 : 1 | NS. | | February 7' 1923. |
| II | 7.8 | | 120 | 18 : 1 | EW. | | " " |
| 17 | 12.0 | | 250 | 20 : 1 | EW. | | " " |
| 23 | 12.0 | | 250 | (1) | EW. | | See note below. |
| D | 37.2 | | | 13 : 10 | EW. | | February 7, 1923. |
| D | 36.1 | | | 13 : 10 | NS. | | " " |
| W | 6.0 | 0.6 mm | 160 | 20 : 1 | V. | | " " |

[1] No. 23 was run at various values for the damping ratio. It was kept at 20 : 1 until Mar. 9, 1923. It was then set at 15 : 1 until Mar. 1, 1917, when it was again changed to 10 : 1 until the end of the month and longer.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Mar. 1 | | *O* | 8 26 15 | | | | (6240) | |
| | | P | 8 36 00 | | | | | |
| | | S | 8 43 49 | | | | | |
| | | i | 8 45 47 | | | | | |
| | | i | 8 47 38 | | | | | |
| | | eL | 8 53 .. | | | | | Small amplitudes. |
| | | L | 8 56 .. | | | | | |
| | | L | 9 00 to 10 00 .. | | | | | |
| | | F | 11 *ca.* | | | | | |
| 2 | | e? | 17 01 44 | | | | | Halifax record contains traces of L, but no P or S. |
| | | e(S) | 17 09 32 | | | | | |
| | | i | 17 19 49 | | | | | |
| | | i | 17 26 45 | | | | | |
| | | L | 17 43 .. | | | | | |
| | | M | 17 57 .. | 23 | | | | |
| | | L | 18 09 .. | 21 | | | | |
| | | L | 18 36 .. | 19 | | | | |
| | | F | 20 05 .. | | | | | |
| 3 | | i | 22 33 18 | | | | | |
| | | e | 22 42 00 | | | | | |
| | | eL | 22 57 .. | | | | | Very small amplitudes. |
| | | L | 23 05 *to* | | | | | |
| | | L | 23 25 .. | | | | | |
| | | F | 23 53 .. | | | | | |
| 4. | | eL | 0 29 .. | | | | | Traces only. |
| | | L | 0 36 .. | | | | | |
| | | F | 1 15 *ca.* | | | | | |
| 4 | | eL | 7 44 .. | | | | | Very small amplitudes. |
| | | L | 7 47 *to* | | | | | |
| | | L | 8 26 .. | | | | | |
| | | F | 9 30 *ca.* | | | | | |
| 10 | | eL | 0 02 .. | | | | | |
| | | L | 0 08 .. | | | | | |
| | | F | 0 38 .. | | | | | |
| 10 | | e | 8 33 .. | | | | | |
| | | e(L or S). | 8 38 .. | | | | | |
| | | L | 8 55 .. | | | | | |
| | | L | 9 00 30 | | | | | |
| | | F | 9 10 *ca.* | | | | | |
| 11 | | *O* | 23 06 45 | | | | 3960 | |
| | | P | 23 14 00 | | | | | |
| | | S | 23 19 45 | | | | | |
| | | eL | 23 25 .. | | | | | Small amplitudes only. |
| | | M | 23 29 .. | | | | | |
| | | F | 0 15 *ca.* | | | | | |
| 12 | | eL | 10 25 .. | | | | | |
| | | L | 10 34 .. | | | | | |
| | | F | 10 50 .. | | | | | |
| 13 | | i | 20 08 38 | | | | | |
| | | eL | 20 19 30 | | | | | |
| | | L | 20 24 30 to 45 .. | | | | | |
| | | F | 21 15 *ca.* | | | | | |
| 14 | | *O* | (20 54 49) | | | | (6, 580) | |
| | | P | (21 04 53) | | | | | |
| | | S | (21 13 00) | | | | | |
| | | eL | 21 21 30 | | | | | |
| | | L | 21 43 .. | | | | | Very small amplitudes throughout. |
| | | M1 | 21 49 .. | 22 | | | | |
| | | M2 | 21 54 30 | 21 | | | | |
| | | L | 22 02 .. | 19 | | | | |
| | | L | 22 08 .. | 18 | | | | |
| | | L | 22 12 30 | 16 | | | | |
| | | F | 23 15 *ca.* | | | | | |
| 15 | | *O* | 5 40 16 | | | | 7,020 | |
| | | P | 5 50 45 | | | | | |
| | | S | 5 59 15 | | | | | |
| | | eL | 6 05 30 | | | | | |
| | | M | 6 18 .. | | | | | |
| | | F | 7 35 .. | | | | | |
| 16 | | *O* | 22 12 33 | | | | 6,320 | Strasbourg wireless gives *O*, 22:15:45; distance, 12,500. |
| | | P | 22 22 22 | | | | | |
| | | S | 22 30 15 | | | | | |
| | | eL | 22 39 15 | | | | | |

CANADA. *Dominion Observatory, Ottawa*—Continued.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Mar. 16 | | L | 22 58 .. | 32 | | | | |
| | | M | 23 12 .. | 22 | | | | |
| | | L | 23 16 .. | 19 | | | | |
| | | L | 23 23 .. | 17 | | | | |
| | | L | 23 30 *to* | | | | | |
| 17 | | L | 0 00 .. | 15 | | | | |
| | | L | 0 05 .. | 14 | | | | |
| | | F | 1 05 *ca.* | | | | | |
| 18 | | eL | 20 45 15 | | | | | |
| | | L | 20 45 48 | | | | | |
| | | M | 20 48 .. | | | | | |
| | | F | | | | | | Micros. |
| 19 | | e | 11 23 .. | | | | | |
| | | S? | 11 26 32 | | | | | |
| | | L | 11 29 .. | | | | | |
| | | M | 11 35 .. | | | | | |
| | | F | 12 27 *ca.* | | | | | |
| 19 | | eL | 16 57 .. | | | | | |
| | | L | 17 15 .. | | | | | |
| | | L | 17 20 .. | | | | | |
| | | L | 17 28 .. | | | | | |
| | | F | 17 45 *ca.* | | | | | |
| 19 | | eL | 21 56 .. | | | | | Small amplitudes. |
| | | L | 22 03 30 | | | | | |
| | | L | 22 05 .. | | | | | |
| | | F | 22 30 *ca* | | | | | |
| 24 | | e | 2 37 .. | | | | | Do. |
| | | L | 2 41 .. | | | | | |
| | | F | 3 00 *ca* | | | | | |
| 24 | | e | 8 51 24 | | | | | |
| | | L | 8 55 24 | | | | | |
| | | L | 8 57 .. | | | | | |
| | | F | 9 10 *ca.* | | | | | |
| 24 | | $e_E$ | 13 00 36 | | | | | Does not appear to have been single abrupt shock: phases seem to result from several shocks, and do not admit o resolution. |
| | | e | 13 04 53 | | | | | |
| | | S | 13 06 .. | | | | | |
| | | eL | 13 18 .. | | | | | |
| | | L | 13 25 .. | | | | | |
| | | M1 | 13 38 30 | 30 | | | | |
| | | M2 | 13 42 30 | 26 | | | | |
| | | L | 13 43 *to* | | | | | |
| | | L | 14 00 .. | 18 | | | | |
| | | L | 14 10 *to* | | | | | |
| | | L | 15 45 .. | 13 | | | | |
| | | F | 15 30 *ca.* | | | | | |
| 26 | | $eL_E$ | 14 57 .. | | | | | |
| | | $L_E$ | 15 00 .. | 40 | | | | |
| | | $L_E$ | 15 02 30 | 24 | | | | |
| | | $L_E$ | 15 10 30 | 21 | | | | Small sinusoidal L waves. |
| | | $L_E$ | 15 14 .. | 18 | | | | |
| | | $L_E$ | 15 24 30 | 22 | | | | |
| | | $L_E$ | 15 32 .. | 20 | | | | |
| | | F | 15 49 *ca.* | | | | | |
| 28 | | e | (5 10) | | | | | Times uncertain |
| | | e | (5 15) | | | | | |
| | | eL? | (5 21) | | | | | |
| | | L | (5 28) *to* | | | | | |
| | | | (6 20) | | | | | |
| | | F | (6 30) | | | | | |

No earthquakes were recorded during March, 1923, at the following station:

COLORADO. *Regis College*, Denver.

Reports for March, 1923, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.

DISTRICT OF COLUMBIA. *Georgetown University*, Washington.

MASSACHUSETTS. *Harvard University*, Cambridge.

MISSOURI. *St. Louis University*, St. Louis.

NEW YORK. *Cornell University*, Ithaca; *Fordham University*, New York.

CANADA. *Dominion Meteorological Service*, Toronto *and* Victoria.

TABLE 3.—*Late reports (instrumental).*

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Feb. 2 | | *O* | 5 08 07 | | | | 6,920 | $L_N$ barely perceptible. |
| | | $P_N$ | 5 18 30 | | | | | |
| | | $e_N$ | 5 20 19 | | | | | |
| | | $S_E$ | 5 27 05 | | | | | |
| | | $S_N$ | 5 26 55 | | | | | |
| | | $e_E$ | 5 31 12 | | | | | |

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tuscon*—Con.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Feb. 2 | | $L1_E$ | 5 41 41 | | | | | |
| | | $L2_E$ | 5 43 46 | 20 | | | | |
| | | $L_N$ | 5 41 .. | | | | | |
| | | $M_E$ | 5 44 10 | 20 | *200 | | | |
| | | $F_E$ | 6 10 .. | | | | | |
| | | $F_N$ | 5 57 .. | | | | | |
| 3 | | *O* | 16 01 41 | | | | 7,320 | $M_E$ off paper at 16:39:26; recorded on magnetograph. |
| | | P1 | 16 12 26 | | | | | |
| | | P2 | 16 12 47 | 4 | | | | |
| | | e | 16 21 00 | 13 | | | | |
| | | $iS_E$ | 16 21 11 | | | | | |
| | | $PS_N$ | 16 21 42 | 30 | | | | |
| | | $i_N$ | 16 22 51 | | | | | |
| | | $e_E$ | 16 24 31 | 28 | | | | |
| | | $e_N$ | 16 25 44 | | | | | |
| | | $e_E$ | 16 27 58 | | | | | |
| | | $SR2_E$ | 16 30 01 | 35 | | | | |
| | | $SR2_N$ | 16 29 49 | 35 | | | | |
| | | $L_E$ | 16 34 08 | 24 | | | | |
| | | $L_N$ | 16 35 02 | 20 | | | | |
| | | $M_E$ | | 17 | *45,000 | | | |
| | | $M_N$ | 16 39 35 | 18 | | *37,500 | | |
| | | $C_N$ | 16 40 20 | | | | | |
| | | F | 19 42 .. | | | | | |
| 8 | | P | 0 37 40 | 3 | | | | Recorded on magnetograph. |
| | | iL | 0 42 50 | 4 | | | | |
| | | $L2_N$ | 0 43 23 | | | | | |
| | | $M_E$ | 0 43 08 | 4 | *1,000 | | | |
| | | $M_N$ | 0 43 29 | 4 | | *1,600 | | |
| | | F | 0 52 .. | | | | | |
| 8 | | e | 14 21 44 | 4 | *200 | *200 | | Local tremors. |
| | | F | 14 27 .. | | | | | |
| 24 | | $S_E$ | 7 52 27 | | | | | |
| | | $S_N$ | 7 52 33 | | | | | |
| | | $SR_N$ | 7 56 35 | | | | | |
| | | $L1_E$ | 8 04 15 | | | | | |
| | | $L2_E$ | 8 10 51 | | | | | |
| | | $L1_N$ | 8 10 40 | 15 | | | | |
| | | $L2_N$ | 8 14 27 | 12 | | | | |
| | | $M_E$ | 8 21 08 | 16 | *300 | | | |
| | | $M_N$ | 8 21 43 | 14 | | *100 | | |
| | | $F_E$ | 9 04 .. | | | | | |
| | | $F_N$ | 8 44 .. | | | | | |
| 27 | | $e_E$ | 20 39 41 | | | | | Local. |
| | | $e_N$ | 20 40 41 | | | | | |
| | | $M_E$ | 20 41 21 | 11 | *100 | | | |
| | | $M_N$ | 20 42 37 | 4 | | *100 | | |
| | | $F_E$ | 20 47 .. | | | | | |
| | | $F_N$ | 20 49 .. | | | | | |

*Trace amplitude.

ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Feb. 2 | | *O* | 5 07 45 | | | | 3,680 | |
| | | $P_E$ | 5 14 39 | | | | | |
| | | $eP_N$ | 5 15 15 | | | | | |
| | | $e_E$ | 5 16 12 | | | | | |
| | | $e_N$ | 5 18 47 | | | | | |
| | | S | 5 20 07 | 10 | | | | |
| | | $SR_E$ | 5 22 25 | | | | | |
| | | $SR_N$ | 5 22 19 | | | | | |
| | | $e_E$ | 5 24 27 | | | | | |
| | | $e_N$ | 5 24 52 | 11 | | | | |
| | | $L1_E$ | 5 26 29 | | | | | |
| | | $L2_E$ | 5 27 27 | | | | | |
| | | $iL_N$ | 5 28 11 | 21 | | | | |
| | | $M_E$ | 5 28 57 | 20 | *2,800 | | | |
| | | $M_N$ | 5 29 28 | 18 | | *4,200 | | |
| | | $F_E$ | 7 46 .. | | | | | |
| | | $F_N$ | 7 39 .. | | | | | |
| 3 | | *O* | 16 01 42 | | | | 3,780 | $L_E$ masked by ac tivity in S. Off paper at 16:20:35. $L_N$ off at 16:21:35; On after 16:32:17. $L_E$ stylus replaced, began 17:11. Recorded by magnetograph. |
| | | P | 16 08 44 | | | | | |
| | | $e_E$ | 16 11 19 | | | | | |
| | | $e_N$ | 16 11 28 | 16 | | *6,000 | | |
| | | $e_N$ | 16 13 19 | 17 | | | | |
| | | iS | 16 14 18 | | | *1,600 | | |
| | | $SR_N$ | 16 16 55 | | | *2,800 | | |
| | | $L1_N$ | 16 19 07 | | | | | |
| | | $L2_N$ | 16 21 .. | | | | | |
| | | $M_E$ | | 22 | *80,000 | | | |
| | | $M_N$ | | 20 | | *80,000 | | |
| | | F | 20 50 .. | | | | | |
| 24 | | *O* | 7 34 32 | | | | 3,590 | |
| | | $P_E$ | 7 41 19 | | | | | |
| | | $PR_E$ | 7 42 25 | 19 | | | | |
| | | S | 7 46 42 | 16 | | | | |
| | | $SR_N$ | 7 48 46 | | | | | |
| | | $L1_E$ | 7 50 35 | | | | | |
| | | $L2_E$ | 7 52 45 | | | | | |
| | | $L1_N$ | 7 51 23 | 19 | | | | |
| | | $L2_N$ | 7 52 58 | 19 | | | | |
| | | $M_E$ | 7 54 20 | 20 | *9,300 | | | |
| | | $M_N$ | 7 54 56 | 16 | | *5,500 | | |
| | | $F_E$ | 9 49 .. | 15 | | | | |
| * | | $F_N$ | 9 45 .. | | | | | |

Trace amplitude.

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| Feb. 2 | | *O* | 5 08 15 | | | | 8,180 | No definite M on N. |
| | | $P_E$ | 5 19 45 | 3 | | | | |
| | | $P_N$ | 5 19 52 | 3 | | | | |
| | | $PR1_E$ | 5 22 43 | | | | | |
| | | $ePR_N$ | 5 24 13 | | | | | |
| | | $ePR_N$ | 5 25 26 | | | | | |
| | | $S_E$ | 5 29 14 | 10 | | | | |
| | | $S_N$ | 5 29 22 | | | | | |
| | | $PS_N$ | 5 30 11 | | | | | |
| | | $SR1_N$ | 5 34 14 | | | | | |
| | | $SR2_N$ | 5 38 06 | | | | | |
| | | $L1_E$ | 5 46 42 | | | | | |
| | | $L2_E$ | 5 49 02 | 20 | | | | |
| | | $L1_N$ | 5 46 26 | | | | | |
| | | $L2_N$ | 5 49 48 | 20 | | | | |
| | | $M_E$ | 5 51 35 | 16 | *200 | | | |
| | | F | 6 40 .. | 16 | | | | |
| 3 | | *O* | 16 02 02 | | | | 8,240 | N stylus off sheet at 16:49:04; E off at 16:48:53. Recorded on the magnetograph. |
| | | P | 16 13 36 | 3 | | | | |
| | | $PR1_E$ | 16 17 08 | | | | | |
| | | $iS_E$ | 16 23 08 | | | | | |
| | | $S_N$ | 16 23 20 | | | | | |
| | | $PS_E$ | 16 23 47 | | | | | |
| | | $PS_N$ | 16 23 39 | | | | | |
| | | $SR1_E$ | 16 28 15 | | | | | |
| | | $SR1_N$ | 16 28 27 | | | | | |
| | | $SR2_N$ | 16 31 33 | 20 | | *1,800 | | |
| | | $e_E$ | 16 33 25 | 60 | *3,500 | | | |
| | | $i_N$ | 16 34 29 | | | | | |
| | | $e_N$ | 16 36 25 | 40 | | | | |
| | | $L1_E$ | 16 37 54 | 31 | | | | |
| | | $L2_E$ | 16 41 08 | 23 | | | | |
| | | $L1_N$ | 16 39 44 | 28 | | | | |
| | | $L2_N$ | 16 41 03 | | | | | |
| | | $M_E$ | | | *45,000 | | | |
| | | $M_N$ | | | | *54,000 | | |
| | | C | 16 58 .. | | | | | |
| | | $F_E$ | 20 09 .. | | | | | |
| | | $F_N$ | 19 27 .. | | | | | |
| 24 | | *O* | 7 34 15 | | | | 8,370 | |
| | | $eP_N$ | 7 46 14 | | | | | |
| | | $S_E$ | 7 55 34 | 16 | | | | |
| | | $S_N$ | 7 55 26 | | | | | |
| | | $SR2_E$ | 8 04 33 | 21 | | | | |
| | | $L1_E$ | 8 10 57 | 34 | | | | |
| | | $L2_E$ | 8 13 16 | 21 | | | | |
| | | $L_N$ | 8 13 08 | 25 | | | | |
| | | $M_E$ | 8 19 35 | 16 | *500 | | | |
| | | $M_N$ | 8 18 49 | 19 | | *500 | | |
| | | $F_E$ | 8 57 .. | 15 | | | | |
| | | $F_N$ | 9 12 .. | 12 | | | | |

* Trace amplitude.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| Feb. 1 | | $P_N$ | 19 42 12 | | | | | E record obscured by overlapping traces. |
| | | $S_N$? | 19 47 47 | | | | | |
| | | $L_N$ | 19 49 30 | 30 | | | | |
| | | $M_N$ | 19 39 54 | 30 | | 130 | | |
| | | $F_N$ | 20 01 .. | | | | | |
| 2 | | $P_N$ | 1 21 53 | | | | | Do. |
| | | $S_N$? | 1 27 16 | 7 | | | | |
| | | $L_N$ | 1 28 30 | 21 | | 60 | | |
| | | $M_N$ | 1 31 23 | 20 | | 80 | | |
| | | $F_N$ | 1 51 .. | | | | | |
| 2 | | *O* | 5 08 05 | | | | 4,630 | |
| | | $P_E$ | 5 16 41 | | | | | |
| | | $P_N$ | 5 16 08 | | | | | |
| | | $S_E$ | 5 22 46 | | | | | |
| | | $S_N$ | 5 22 30 | 20 | | 220 | | |
| | | $e_E$ | 5 24 48 | | | | | |
| | | $SR1_N$ | 5 25 22 | | | | | |
| | | $SR2_E$ | 5 26 18 | | | | | |
| | | $SR2_N$ | 5 26 30 | 18 | | 150 | | |
| | | $L_E$ | 5 29 21 | 22 | | | | |
| | | $L_N$ | 5 28 10 | 22 | | | | |
| | | $M_E$ | 5 30 08 | 20 | 310 | | | |
| | | $M_N$ | 5 32 45 | 19 | | 420 | | |
| | | F | 6 55 .. | | | | | |
| 3 | | *O* | 16 01 46 | | | | 5,020 | Motion after L too rapid to register; E visible after 16:29, N after 16:35; paper changed 17:08 to 17:19; E on new sheet obscured by overlapping traces. Recorded on magnetograph. (*) indicates approximate amplitudes. |
| | | iP | 16 10 15 | 7 | 60 | 110 | | |
| | | $e_N$ | 16 16 00 | | | | | |
| | | $iS_E$ | 16 16 58 | 11 | 600 | | | |
| | | $iS_N$ | 16 16 58 | 16 | | 790 | | |
| | | $L_E$ | 16 22 18 | 16 | *1,700 | | | |
| | | $L_N$ | 16 22 12 | 16 | | *1,100 | | |
| | | $LR_N$ | 18 57 53 | | | | | |
| | | $iLR_N$ | 19 03 17 | 21 | | 210 | | |
| | | F | 20 53 .. | | | | | |

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Con.

| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| Feb 8 | | e | 0 16 .. | | | | | Very slight. |
| | | F | 0 23 .. | | | | | |
| 8 | | $e_N$ | 8 11 00 | | | | | Activity on E well defined but of small magnitude. |
| | | $e_E$ | 8 11 10 | 13 | 10 | | | |
| | | $e_E$ | 8 14 04 | 8 | | | | |
| | | $e_E$ | 8 17 20 | | | | | |
| | | $e_E$ | 8 34 50 | | | | | |
| | | $F_E$ | 8 36 .. | | | | | |
| | | $F_N$ | 8 27 .. | | | | | |
| 10 | | $e_E$ | 7 11 33 | | | | | An irregularity in the microseisms. |
| | | $e_N$ | 7 12 28 | | | | | |
| | | F | 7 13 .. | | | | | |
| 11 | | $e_E$ | 22 59 40 | | | | | |
| | | $e_E$ | 23 04 20 | 20 | | | | |
| | | $e_N$ | 23 04 30 | 15 | | | | |
| | | $M_E$ | 23 04 51 | 20 | 30 | | | |
| | | $M_N$ | 23 05 18 | 13 | | 50 | | |
| | | $F_E$ | 23 18 .. | | | | | |
| | | $F_N$ | 23 26 .. | | | | | |
| 12 | | *O* | 1 58 26 | | | | 5,120 | P merely an irregularity in micros; preliminary phases exceptionally weak. |
| | | P? | 2 07 02 | | | | | |
| | | $S_N$ | 2 13 51 | | | | | |
| | | $SR1_E$ | 2 17 20 | | | | | |
| | | $SR1_N$ | 2 17 28 | 8 | | | | |
| | | $L_E$ | 2 20 11 | 28 | | | | |
| | | $L_N$ | 2 19 55 | 21 | | | | |
| | | $M_E$ | 2 22 41 | 21 | 60 | | | |
| | | $M_N$ | 2 21 37 | 20 | | 80 | | |
| | | $F_E$ | 2 49 .. | | | | | |
| | | $F_N$ | 2 45 .. | | | | | |
| 16 | | $e_E$ | 9 35 10 | | | | | |
| | | $e_N$ | 9 35 .. | | | | | |
| | | $M_E$ | 9 36 34 | 11 | 10 | | | |
| | | F | 9 40 .. | | | | | |
| 19 | | e | 0 02 .. | | | | | |
| | | $F_E$ | 0 08 .. | | | | | |
| | | $F_N$ | 0 17 .. | | | | | |
| 21 | | $e_N$ | 4 11 .. | | | | | |
| | | $F_N$ | 4 23 .. | | | | | |
| 23 | | $i_E$ | 6 13 46 | 10 | 25 | | | |
| | | $e_N$ | 6 14 30 | | | | | |
| | | $e_N$ | 6 24 27 | | | | | |
| | | $L_E$ | 6 35 25 | 19 | 15 | | | |
| | | $F_E$ | 6 43 .. | | | | | |
| | | $F_N$ | 6 34 .. | | | | | |
| 24 | | *O* | 7 34 36 | | | | 4,900 | L doubtful on account preceding activity; actual Me occurs during SR. |
| | | P | 7 42 57 | 7 | | 15 | | |
| | | PR1 | 7 44 40 | | | | | |
| | | $e_N$ | 7 48 52 | 13 | | 15 | | |
| | | $iS_E$ | 7 49 34 | 15 | 85 | | | |
| | | $iS_N$ | 7 49 34 | 20 | | 160 | | |
| | | $SR1_E$ | 7 53 00 | | | | | |
| | | $SR2_N$ | 7 53 18 | 14 | | 130 | | |
| | | $L_E$ | 7 55 21 | | | | | |
| | | $L_N$ | 7 54 46 | | | | | |
| | | $M_E1$ | 7 53 40 | 15 | 180 | | | |
| | | $M_E2$ | 7 55 ... | 16 | 150 | | | |
| | | $M_N$ | 7 56 00 | 16 | | 200 | | |
| | | $F_E$ | 10 37 .. | | | | | |
| | | $F_N$ | 10 40 .. | | | | | |
| 25 | | e | 14 58 .. | | | | | Barely perceptible. |
| | | F | 15 03 .. | | | | | |
| 27 | | e | 20 55 .. | | | | | Nothing definite. |
| | | F | 21 03 .. | | | | | |

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| Feb. 3 | | $ePR1_E$ | 16 19 53 | | | | | N stylus off sheet sheet at 16:55:13. Paper changed during P, and pendulum adjusted during S. |
| | | $SR2_E$ | 16 39 48 | | | | | |
| | | $SR2_N$ | 16 39 44 | | | | | |
| | | $e_E$ | 16 42 05 | | | | | |
| | | $e_N$ | 16 45 36 | | | | | |
| | | $L_E$ | 16 52 15 | | | | | |
| | | $iL_N$ | 16 51 02 | | | | | |
| | | $M_E$ | 17 00 35 | 19 | *25,000 | | | |
| | | $M_N$ | | | | *38,000 | | |
| | | $C_E$ | 17 06 .. | 18 | | | | |
| | | $F_E$ | 19 25 .. | | | | | |
| 24 | | $e_E$ | 8 24 18 | 21 | | | | |
| | | $e_N$ | 8 28 47 | | | | | |
| | | $M_E$ | 8 31 42 | 18 | *200 | | | |
| | | $M_N$ | 8 32 10 | 19 | | *100 | | |
| | | $F_E$ | 8 53 .. | | | | | |
| | | $F_N$ | 8 51 .. | | | | | |

* Trace amplitude.

DISTRICT OF COLUMBIA. *Georgetown University, Washington.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Jan. 11 | | $L_N$ | 4 35 44 | | | | | Heavy micros. |
| | | F | 4 40 .. | | | | | |
| 22 | | $iP_E$ | 9 11 27 | | | | | Do. |
| | | $eP_N$ | 9 11 27 | | | | | |
| | | iS | 9 17 12 | | | | | |
| | | $SR_N$ | 9 20 53 | | | | | |
| | | $eL_E$ | 9 23 00 | | | | | |
| | | $eL_N$ | 9 22 42 | | | | | |
| | | $M_E$ | 9 27 07 | | *11,500 | | | |
| | | $M_N$ | 9 24 40 | | | *24,400 | | |
| | | F | 12 *post.* | | | | | |
| 27 | | $eP_E$? | 8 12 41 | | | | | Do. |
| | | $eP_N$ | 8 12 41 | | | | | |
| | | $S_E$? | 8 14 .. | | | | | |
| | | $S_N$ | 8 14 02 | | | | | |
| | | F | 8 40 .. | | | | | |

* Trace amplitude.

CANADA. *Dominion Observatory, Ottawa.*

*Seismologic station, Dominion Observatory.*

[$\phi$=45° 23′ 38″ N. $\lambda$=75° 42′ 57″ W. h=83m. Lithologic foundation: boulder clay over limestone (Ordovician). Time: Mean Greenwich, midnight to midnight. Time correction: within .25s.]

INSTRUMENTS—FIXED CONSTANTS.

| Instrument. | Symbol. | Registration. | Damping. | Paper speed. | Mass. |
|---|---|---|---|---|---|
| Bosch | I | Photographic | Air | 15 mm. per min. | 200 g. |
| Do | II | do | Magnetic | do | Do. |
| Milne-Shaw | 17 | do | do | 8 mm. per min. | 1 lb. |
| Do | 23 | do | do | do | Do. |
| Deformation | D | do | Air | 17 mm. per hour. | 20 g. ca. |
| Spindler-Hoyer | W | Smoked sheet | do | 15 mm. per min. | 80 kgm. |

INSTRUMENTS—DETERMINED CONSTANTS.

| Instrument. | To— | r. | v. | ε. | Comp. | l. | Determined. |
|---|---|---|---|---|---|---|---|
| I | 5.5 | | 120 | 2:1 | NS. | | December, 1922. |
| II | 6.5 | | 120 | aper. | EW. | | Do. |
| 17 | 12.0 | | 250 | 20:1 | EW. | | Do. |
| 23 | 12.0 | | 250 | 20:1 | EW. | | Do. |
| D | 37.2 | | | 13:10 | EW. | | Do. |
| D | 36.1 | | | 13:10 | NS. | | Do. |
| W | 6.0 | | 160 | 20:1 | V. | | Do. |

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Jan. 2 | | $e_E$ | 22 58 42 | | | | | NS lost in heavy micros. |
| | | eL | 23 09 30 | | | | | |
| | | L | 23 17 .. | 22 | | | | |
| 3 | | F | 0 05 *ca* | | | | | |
| 8 | | $i_E$ | 22 12 08 | | | | | |
| | | eL | 22 24 30 | | | | | |
| | | F | 22 50 .. | | | | | |
| 11 | | $e_E$ | 4 46 .. | | | | | |
| | | $eL_E$ | 4 47 30 | | | | | |
| | | $M_E$ | 4 48 48 | | | | | |
| | | F | 4 57 .. | | | | | |
| 12 | | $eL_E$ | 19 50 .. | | | | | Barely discernible on No. 17 only. |
| | | $L_E$ | 19 55 .. | | | | | |
| | | F | 20 05 .. | | | | | |
| 12 | | $e_E$ | 21 31 .. | | | | | Very faintly recorded on 17 only |
| | | $eL_E$ | 21 33 .. | | | | | |
| | | F | | | | | | Lost in micros. |
| 14 | | $eL_E$ | 13 35 to | | | | | |
| | | | 13 50 .. | | | | | Can just be detected. |
| | | F | | | | | | Lost in micros. |
| 20 | | ie | 21 57 41 | | | | | |
| | | $eL_E$ | 22 08 .. | | | | | |
| | | $L_E$ | 22 16 .. | 21 | | | | |
| | | F | 22 35 .. | | | | | |
| 21 | | $i_E$ | 4 33 37 | | | | | On No. 17 only. |
| | | $eL_E$ | 4 55 .. | 12 | | | | |
| | | $L_E$ | 4 59 to | | | | | |
| | | | 5 06 .. | | | | | |
| | | F | 5 26 .. | | | | | |
| 21 | | e | 14 07 30 | | | | | Sinusoidal L waves of small amplitude and with a beautiful gradation in period from 28 sec. to 15 sec. |
| | | eS? | 14 09 42 | | | | | |
| | | eL | 14 32 .. | | | | | |
| | | L | 14 34 .. | 28 | | | | |
| | | L | 14 57 .. | 15 | | | | |
| | | F | 15 00 *ca* | | | | | |
| 22 | | e? | 1 18 .. | | | | | On 17. |
| | | e | 1 20 18 | | | | | Micros obscure NS. |
| | | e | 1 22 .. | | | | | Sinusoidal L waves of small amplitude predominate. |
| | | $eS?_E$ | 1 23 48 | | | | | |
| | | $eL_E$ | 1 39 .. | | | | | |
| | | $L_E$ | 1 54 .. | | | | | |
| | | $L_E$ | 2 10 .. | 19 | | | | |
| | | F | 3 25 .. | | | | | |

CANADA. *Dominion Observatory, Ottawa*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Jan. 22 | | O | 9 04 10 | | | | 3,880 | |
| | | P | 9 11 19 | | | | | Press report tremor felt at Sacramento, Calif., and Reno, Nev. |
| | | PR2 | 9 12 30 | | | | | |
| | | S | 9 16 59 | | | | | |
| | | SR2 | 9 19 17 | | | | | |
| | | eL | 9 20 44 | | | | | |
| | | M | 9 26 45 | 19 | 500 | | | On No. 17. |
| | | F | 12 *ca* | | | | | |
| 26 | | e | 21 50 28 | | | | | Faint traces only. |
| | | i | 21 52 .. | | | | | |
| | | eL | 22 00 .. | | | | | |
| | | F | 22 30 .. | | | | | |
| 27 | | e | 8 09 41 | | | | | |
| | | eL | 8 14 .. | | | | | |
| | | M1 | 8 16 08 | | | | | |
| | | M2 | 8 17 23 | | | | | |
| | | F | 9 09 .. | | | | | |
| Feb. 1 | | $e_E$ | 19 45 38 | | | | | |
| | | $e_E$ | 19 55 38 | | | | | |
| | | $eL_E$ | 20 02 39 | | | | | Sinusoidal L waves. |
| | | L | 20 21 .. | 34 | 63 | | | |
| | | L | 20 36 .. | 18 | | | | |
| | | F | 21 50 .. | | | | | |
| 2 | | *O* | 1 16 53 | | | | 6500 | |
| | | P | 1 26 53 | | | | | |
| | | S | 1 34 56 | | | | | |
| | | L | 1 41 46 | | | | | |
| | | M | 1 49 .. | 20 | 38 | | | |
| | | L | 1 56 .. | | | | | |
| | | F | 3 25 *ca.* | | | | | Lost in micros. |
| 2 | | *O* | 5 08 21 | | | | 7260 | |
| | | P | 5 19 03 | | | | | |
| | | S | 5 27 45 | | | | | |
| | | SR1 | 5 32 41 | | | | | |
| | | eL | 5 36 00 | | | | | |
| | | L | 5 40 .. | 43 | | | | |
| | | $M1_E$ | 5 48 .. | 17 | 140 | | | |
| | | $M2_E$ | 5 54 .. | 17 | 140 | | | |
| | | L | 6 05 .. | 15 | | | | |
| | | L | 6 20 .. | 16 | | | | |
| | | L | 6 40 .. | 15 | | | | |
| | | L | 6 55 .. | 15 | | | | |
| | | L | 7 25 .. | 15 | | | | |
| | | L | 7 51 .. | 15 | | | | |
| | | L | 8 00 .. | 15 | | | | |
| | | L | 8 20 .. | 15 | | | | |
| | | F | 9 10 *ca.* | | | | | |
| 3 | | *O* | 16 01 56 | | | | 7620 | Saskatoon record indicates distance of 5750; Halifax, 8440 (?) |
| | | P | 16 12 57 | | | | | |
| | | S | 16 21 58 | | | | | |
| | | SR2 | 16 29 50 | | | | | |
| | | eL | 16 34 00 | | | | | |
| | | M1 | 16 42 .. | | | | | |
| | | M2 | 16 45 40 | 16 | 4400 | | | |
| | | L | 17 00 .. | 16 | | | | |
| | | L | 18 00 .. | 16 | | | | |
| | | L | 19 00 .. | 16 | | | | |
| | | L | 21 00 .. | 14 | | | | |
| | | L | 23 04 .. | | | | | |
| 4 | | F | 7 00 .. | | | | | |
| 4 | | eL | 11 47 .. | | | | | Small amplitude L; afterquake to preceding. |
| | | eL | 12 55 .. | | | | | |
| | | eL | 13 08 .. | | | | | |
| | | F | 14 10 .. | | | | | |
| 4 | | eL | 16 20 .. | | | | | Faint; registered only on Milne-Shaw. |
| | | F | 17 00 .. | | | | | |
| 4 | | eL | 17 55 .. | | | | | Do. |
| | | F | 18 07 .. | | | | | |
| 4 | | eL | 18 51 .. | | | | | |
| | | L | 19 10 .. | | | | | |
| | | L | 19 15 .. | 16 | | | | |
| | | F | 19 25 .. | | | | | |
| 5 | | e | 3 30 .. | | | | | |
| | | eL | 4 00 .. | | | | | |
| | | L | 4 04 .. | 13 | | | | |
| | | F | 4 40 .. | | | | | |
| 5 | | $eL_E$ | 8 37 .. | | | | | |
| | | F | 8 55 *ca.* | | | | | |
| 5 | | Le | 12 21 .. | | | | | |
| | | F | 12 50 *ca.* | | | | | |
| 5 | | $eL_E$ | 23 01 30 | | | | | |
| | | $L_E$ | 23 03 .. | 15 | | | | |
| | | $L_E$ | 23 26 .. | | | | | |
| | | $L_E$ | 23 35 .. | 15 | | | | |
| | | $L_E$ | 23 40 .. | | | | | |
| 6 | | F | 0 05 *ca.* | | | | | |
| 6 | | eL | 13 06 .. | | | | | Faint traces only. |
| | | F | 13 25 *ca.* | | | | | |
| 6 | | eL | 22 28 .. | | | | | Do. |
| | | F | 22 45 *ca.* | | | | | |
| 8 | | O | 0 33 23 | | | | 3,660 | |
| | | P | 0 40 15 | | | | | |
| | | S | 0 45 42 | | | | | |
| | | eL | 0 50 .. | | | | | |
| | | L | 0 52 .. | | | | | |
| | | L | 1 04 .. | | | | | |
| | | F | 1 30 *ca.* | | | | | |

CANADA. *Dominion Observatory, Ottawa*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Feb. 8 | | eL | 3 56 .. | 36 | | | | NS lost |
| | | L | 4 00 .. | 22 | | | | |
| | | L | 4 10 .. | 15 | | | | |
| | | F | 4 20 .. | | | | | |
| 8 | | e? | 7 53 18 | | | | | |
| | | e? | 8 02 .. | | | | | |
| | | eL | 8 26 .. | 22 | | | | |
| | | L | 8 29 .. | | | | | |
| | | L | 8 38 .. | 15 | | | | |
| | | F | 9 10 .. | | | | | |
| [illegible] | | e | 14 24 12 | | | | | |
| | | eL | 14 32 .. | | | | | |
| | | F | | | | | | Lost in changing sheet. |
| 9 | | $eL_E$ | 11 33 .. | | | | | Traces very small. |
| | | $eL_E$ | 12 05 .. | | | | | |
| | | F | 12 28 .. | | | | | |
| 11 | | $eL_E$ | 1 50 .. | | | | | |
| | | $L_E$ | 1 53 .. | | | | | |
| | | $L_E$ | 2 00 .. | | | | | |
| | | F | 2 10 .. | | | | | |
| 11 | | e | 17 43 .. | | | | | Small amplitudes. |
| | | eL | 17 49 .. | 18 | | | | |
| | | L | 17 50 .. | 15 | | | | |
| | | F | 18 27 .. | | | | | |
| 11 | | (O) | 22 59 47 | | | | (2,930) | Interpretation of increase in period of L at 0:35:30 not known. |
| | | (P) | 23 05 37 | | | | | |
| | | (S) | 23 10 15 | | | | | |
| | | eL | 23 13 00 | | | | | |
| | | L | 23 25 .. | 16 | | | | |
| | | L | 23 32 .. | 16 | | | | |
| | | L | 23 43 .. | 15 | | | | |
| 12 | | L | 0 05 .. | 15 | | | | |
| | | L | 0 35 30 | 30 | | | | |
| | | F | 0 55 .. | | | | | |
| 12 | | *O* | 2 09 01 | | | | 6,160 | |
| | | P | 2 18 41 | | | | | |
| | | S | 2 26 26 | | | | | |
| | | eL | 2 31 .. | | | | | |
| | | L | 2 35 30 | | | | | |
| | | $M_E$ | 2 43 .. | 22 | 58 | | | |
| | | L | 3 00 .. | | | | | |
| | | F | 4 10 *ca.* | | | | | |
| 12 | | $eL_E$ | 113 18 .. | | | | | |
| | | $L_E$ | 3 22 .. | | | | | |
| | | F | 13 38 .. | | | | | |
| 14 | | $eL_E$ | 17 59 .. | | | | | Faint traces only. |
| | | $L_E$ | 18 08 .. | | | | | |
| | | F | 18 22 *ca.* | | | | | |
| 15 | | eL | 23 14 to | | | | | |
| | | | 23 31 .. | | | | | Heavy micros. |
| 16 | | L | 7 15 42 | | | | | Do |
| | | F | 7 35 .. | | | | | |
| 16 | | e | 9 37 36 | | | | | Do. |
| | | eL | 9 50 30 | | | | | |
| | | F | 10 12 *ca.* | | | | | |
| 18 | | *O* | 23 50 25 | | | | 5,880 | |
| | | P | 23 59 49 | | | | | |
| 19 | | S | 0 07 19 | | | | | L taper off to very small amplitudes after M. |
| | | eL | 0 12 30 | | | | | |
| | | L | 0 17 .. | | | | | |
| | | Me | 0 23 24 | 19 | 26 | | | |
| | | F | 2 00 .. | | | | | |
| 19 | | $e_E$ | 6 39 26 | | | | | |
| | | $e_E$ | 6 51 24 | | | | | |
| | | $e_E$ | 6 56 12 | | | | | |
| | | $eL_E$ | 7 10 .. | | | | | |
| | | $L_E$ | 7 17 .. | | | | | |
| | | $L_E$ | 7 36 30 | | | | | |
| | | F | 8 25 *ca.* | | | | | |
| 21 | | eL | 1 01 .. | | | | | Small amplitudes. |
| | | L | 1 09 .. | | | | | |
| | | L | 1 20 .. | | | | | |
| | | L | 1 32 .. | | | | | |
| | | F | 1 50 *ca.* | | | | | |
| 21 | | e | 3 40 .. | | | | | Do. |
| | | eL | 3 46 .. | | | | | |
| | | L | 4 00 .. | | | | | |
| | | L | 4 15 .. | | | | | |
| | | L | 4 25 .. | | | | | |
| | | F | 4 45 *ca.* | | | | | |
| 23 | | *O* | 6 05 28 | | | | 4,750 | |
| | | P | 6 13 39 | | | | | |
| | | i | 6 14 23 | | | | | |
| | | S | 6 20 08 | | | | | Period of L extremely irregular; amplitudes small. |
| | | eL | 6 25 30 | | | | | |
| | | L | 6 31 .. | | | | | |
| | | L | 6 43 .. | | | | | |
| | | L | 6 53 .. | | | | | |
| | | L | 7 04 .. | | | | | |
| | | F | 8 17 .. | | | | | |

CANADA. *Dominion Observatory, Ottawa*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Feb. 23 | | *O* | 7 34 48 | | | | 7,390 | |
| | | P | 7 45 37 | | | | | |
| | | S | 7 54 26 | | | | | |
| | | SR1 | 7 59 32 | | | | | |
| | | SR2 | 8 02 08 | | | | | |
| | | eL | 8 05 .. | 45 | | | | |
| | | L | 8 10 .. | | | | | |
| | | $M_E$ | 8 14 30 | 16 | 410 | | | |
| | | L | 8 20 to | 8 | | | | |
| | | | 11 00 .. | 8 | | | | |
| | | F | 11 40 .. | | | | | |

HALIFAX RECORD.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *O* | 7 36 40 | | | | 7,620 | |
| | | P | 7 47 41 | | | | | |
| | | S | 7 56 42 | | | | | |
| | | eL | 8 04 .. | | | | | |
| | | M1 | 8 15 .. | | | | | |
| | | M2 | 8 21 .. | | | | | |
| | | F | 9 20 *ca.* | | | | | |

SASKATOON RECORD.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *O* | 7 36 34 | | | | 5,400 | Difference in O probably due to clock errors in Saskatoon and Halifax. |
| | | P | 7 45 28 | | | | | |
| | | S | 7 52 32 | | | | | |
| | | eL | 8 00 .. | | | | | |
| | | L | 8 02 .. | | | | | Epicentre in Kamchatka. |
| | | M1 | 8 05 30 | | | | | |
| | | M2 | 8 11 30 | | | | | |
| | | F | 9 *ca.* | | | | | |
| 24 | | eL | 18 58 .. | | | | | |
| | | F | 19 05 .. | | | | | Very small amplitudes. |
| 25 | | eL | 4 37 .. | | | | | |
| | | L | 4 39 .. | | | | | |
| | | F | 5 00 .. | | | | | |
| 27 | | *O* | 20 39 12 | | | | 2,850 | |
| | | *P* | 20 44 54 | | | | | |
| | | S | 20 49 26 | | | | | |
| | | eL | 20 51 38 | | | | | |
| | | L | 20 53 45 | | | | | |
| | | F | 21 30 *ca.* | | | | | |
| 28 | | *O* | 22 20 33 | | | | (2,640) | |
| | | P? | 22 25 55 | | | | | |
| | | S | 22 30 11 | | | | | Small amplitudes only. |
| | | eL | 22 34 .. | | | | | |
| | | M | 22 38 .. | | | | | |
| | | F | 23 18 .. | | | | | |

CANADA. *Meteorological Service of Canada, Toronto.*

| 1923. | | | H. m. s. | Sec. | μ. | μ. | Km. | |
|---|---|---|---|---|---|---|---|---|
| Feb. 1 | | L | 20 26 36 | | | | | Distant quake. |
| | | eL | 20 32 18 | | | | | |
| | | M | 20 34 54 | | *500 | | | |
| | | L | 21 05 36 | | | | | |
| | | F | 21 14 36 | | | | | |
| 2 | | e | 1 28 18 | | | | | |
| | | L | 1 35 54 | | | | | |
| | | L | 1 45 00 | | | | | |
| | | M | 1 53 12 | | *1,300 | | | |
| | | L | 1 59 12 | | | | | |
| | | F | 3 11 24 | | | | | |
| 2 | | P | 5 19 36 | | | | | S fairly large. |
| | | iS | 5 28 24 | | *400 | | | |
| | | iL | 5 37 00 | | | | | |
| | | i | 5 43 54 | | | | | |
| | | L | 5 47 12 | | | | | |
| | | M | 5 50 12 | | *6,700 | | 7,380 | |
| | | L | 7 04 30 | | | | | |
| | | eL | 7 21 54 | | | | | |
| | | eL | 8 07 00 | | | | | |
| | | F | 8 25 00 | | | | | |
| 3 | | iP | 16 13 18 | | *1,000 | | | Large amplitude P. |
| | | i | 16 15 12 | | | | | |
| | | i | 16 17 48 | | | | | |
| | | iS | 16 22 06 | | *4,000 | | | |
| | | i | 16 26 48 | | | | | |
| | | i | 16 31 30 | | | | | |
| | | iL | 16 36 48 | | *30,000 | | 7,380 | From 6:39 to 17:09 the boom moved a large number of times over the range of the paper. |
| | | iL | 16 37 48 | | | | | |
| | | eL | 18 56 48 | | | | | |
| | | eL | 19 15 54 | | | | | |
| | | eL | 19 51 42 | | | | | |
| | | eL | 20 39 36 | | | | | |
| | | F | 22 29 06 | | | | | |
| 4 | | eL | 2 50 36 | | | | | Thickening. |
| | | F | 3 03 24 | | *50 | | | |
| 4 | | L | 13 13 06 | | | | | |
| | | F | 13 23 12 | | *50 | | | |
| 5 | | L | 12 21 06 | | | | | Thickening. |
| | | F | 12 31 18 | | *100 | | | |

CANADA. *Meteorological Service of Canada, Toronto*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Feb. 5 | | L | 23 35 42 | | | | | |
| | | eL | 23 37 06 | | | | | |
| | | M | 23 39 12 | | *300 | | | |
| | | F | 0 06 24 | | | | | |
| 8 | | e | 0 53 00 | | | | | |
| | | eL | 0 57 12 | | | | | |
| | | M | 0 58 30 | | *200 | | | |
| | | eL | 1 06 06 | | | | | |
| | | F | 1 18 36 | | | | | |
| 8 | | eL | 8 30 48 | | | | | |
| | | eL | 8 32 24 | | | | | |
| | | M | 8 38 12 | | *200 | | | |
| | | F | 8 48 30 | | | | | |
| 11 | | eL | 17 52 54 | | | | | Doubtful as to being seismic. |
| | | M | 17 55 12 | | *200 | | | |
| | | eL | 18 03 42 | | | | | |
| | | F | 18 07 24 | | | | | |
| 11 | | L | 23 22 54 | | | | | Uniform and continuous vibrations up to 23:35 from eL. |
| | | eL | 23 23 54 | | | | | |
| | | M | 23 25 30 | | *400 | | | |
| | | F | 23 54 42 | | | | | |
| 12 | | S? | 2 27 18 | | | | | |
| | | L | 2 35 12 | | | | | |
| | | eL | 2 36 30 | | | | | |
| | | M | 2 39 00 | | *1,300 | | | |
| | | eL | 2 55 42 | | | | | |
| | | F | 3 03 18 | | | | | |
| 12 | | L | 3 26 54 | | | | | May be return waves from antipodes. |
| | | F | 3 31 24 | | | | | |
| 14 | | L | 17 38 42 | | | | | |
| | | F | 17 44 18 | | *100 | | | Thickening. |
| 19 | | eL | 0 17 36 | | | | | |
| | | M | 0 20 30 | | *400 | | | |
| | | eL | 0 29 54 | | | | | |
| | | F | 0 43 12 | | | | | |
| 21 | | eL | 1 33 12 | | | | | |
| | | M | 1 36 18 | | *200 | | | |
| | | F | 1 46 54 | | | | | |
| 23 | | L | 7 10 00 | | | | | |
| | | L | 7 22 42 | | *100 | | | |
| | | F | 7 34 12 | | | | | |
| 24 | | PR | 7 53 54 | | | | | |
| | | iS | 7 56 06 | | *1,000 | | | |
| | | SR or S. | 7 57 24 | | | | | |
| | | eL | 8 00 18 | | | | | |
| | | eL | 8 03 30 | | | | | |
| | | i | 8 10 36 | | | | | |
| | | i | 8 13 42 | | | | | |
| | | M | 8 15 24 | | *10,000 | | | |
| | | eL | 8 35 42 | | | | | |
| | | eL | 8 40 06 | | | | | |
| | | iL | 9 07 18 | | | | | |
| | | L | 9 20 30 | | | | | |
| | | eL | 9 53 12 | | | | | |
| | | eL | 10 10 36 | | | | | |
| | | eL | 10 36 18 | | | | | |
| | | F | 11 16 42 | | | | | |

CANADA. *Meteorological Service of Canada, Victoria.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Jan. 21 | | P | ?14 02 17 | 10 | | | 3,620 | |
| | | S | ?14 07 42 | 14 | | | | |
| | | L | 14 17 52 | 27 | | | | |
| | | M | 14 20 02 | 23 | 4 | | | |
| | | F | 14 54 10 | | | | | |
| | | P | ?14 01 27 | 10 | | | 4,310 | |
| | | S | ?14 07 32 | 14 | | | | |
| | | M | 14 17 42 | 30 | 3 | | | |
| | | F | 14 32 07 | | | | | |
| 20 | | P | ?22 01 55 | 7 | | | | |
| | | L | 22 22 30 | 25 | | | | |
| | | M | 22 25 30 | 20 | 2 | | | |
| 22 | | P | 1 07 17 | 6 | | | 9,180 | |
| | | S | 1 17 37 | 10 | | | | |
| | | L | 1 30 20 | 15 | | | | |
| | | M | 1 37 15 | 25 | 5 | | | |
| | | F | 2 37 25 | | | | | |
| | | P | 1 07 17 | 6 | | | 9,060 | |
| | | S | 1 17 31 | 10 | | | | |
| | | L | 1 30 25 | 15 | | | | |
| | | M | 1 38 00 | 20 | 4 | | | |
| | | F | 2 22 37 | | | | | |
| 22 | | Pz | 9 06 16 | 3 | | | 830 | Probably off Cape Mendocino. |
| | | Sz | 9 07 46 | 6 | | | | |
| | | Lz | 9 08 43 | 8 | | | | |
| | | Mz | 9 10 18 | 10 | 102 | | | |

CANADA. *Meteorological Service of Canada, Victoria*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Jan. 22 | | P | 9 06 16 | 6 | | | 830 | |
| | | S | 9 07 46 | | | | | |
| | | L | 9 07 46 | 25 | | | | |
| | | M | 9 10 51 | 25 | 1,518 | | | |
| | | F | 12 49 11 | | | | | |
| | | P | 9 06 16 | 6 | | | 875 | |
| | | S or L. | 9 07 51 | 25 | | | | |
| | | M | 9 09 51 | 25 | | 1,250 | | |
| | | F | 12 40 01 | | | | | |
| 24 | | P | ?1 55 02 | 6 | | | 260 | |
| | | M | 1 55 31 | 20 | 9 | | | |
| | | F | 2 01 28 | | | | | |
| | | P | ?1 55 02 | 6 | | | 490? | |
| | | M | 1 55 56 | 15 | 4 | | | |
| 26 | | P | 21 47 41 | 6 | | | 2,560? | |
| | | L | 21 51 51 | 12 | | | | |
| | | M | 21 53 15 | 12 | 1 | | | |
| | | F | 22 24 01 | | | | | |
| | | P | 21 47 41 | 6 | | | | |
| | | L | 21 57 55? | | | | | |
| | | M | 21 59 41 | 12 | 1 | | | |
| | | F | 22 25 11 | | | | | |
| 27 | | P | 8 07 30 | 10 | | | | |
| | | L | 8 10 35 | 20 | | | | |
| | | M | 8 13 50 | 20 | 38 | | | |
| | | F | 9 07 40 | | | | | |
| | | P | 8 07 40 | 10 | | | 770 | |
| | | S | 8 09 04 | 15 | | | | |
| | | L | 8 11 00 | 20 | | | | |
| | | M | 8 14 25 | 15 | 25 | | | |
| | | F | 9 08 40 | | | | | |
| Feb. 1 | | P | 19 48 48 | 10 | | | 5,320 | |
| | | S | 19 55 48 | 12 | | | | |
| | | L | 20 07 03 | 30 | | | | |
| | | M | 20 07 55 | 35 | 67 | | | |
| | | F | 20 37 03 | | | | | |
| | | P | 19 48 48 | 10 | | | 4,650 | |
| | | S | 19 55 11 | 12 | | | | |
| | | L | 20 07 03 | 30 | | | | |
| | | M | 20 07 53 | 35 | 42 | | | |
| | | F | 20 30 33 | | | | | |
| 2 | | P | 1 15 29 | 6 | | | 4,480 | |
| | | S | ?1 21 43 | 20 | | | | |
| | | L | 1 29 03 | 25 | | | | |
| | | M | 1 35 18 | 20 | 29 | | | |
| | | F | 2 55 03 | | | | | |
| 2 | | P | 5 16 03 | 6 | | | 1,530 | S may be PR1; L may be S. |
| | | S | 5 18 43 | 15 | | | | |
| | | L | 5 22 58 | 22 | | | | |
| | | M | 5 32 03 | 25 | 187 | | | |
| | | F | ?8 50 00 | | | | | |
| 3 | | P | 16 10 03 | | | | | Too rapid to record clearly. |
| | | M | ?16 23 34 | 25 | 1,732 | | | |
| | | F | 22 08 03 | | | | | |
| | | P | 16 10 09 | 15 | | | | Do. |
| | | M | ? | 25 | | 1,071 | | |
| | | F | 22 06 58 | | | | | |
| | | Pz | 16 10 10 | 5 | | | | Probably lat. 41° N., long. 155° W. |
| | | Sz | 16 14 09 | 15 | | | 2,430 | |
| | | Lz | 16 21 07 | 32 | | | | |
| | | Mz | 16 26 11 | 20 | 156 | | | |
| | | Fz | 18 27 00 | | | | | |
| 3 | | P | ?22 44 37 | 6 | | | 2,130 | |
| | | S | 22 48 12 | 10 | | | | |
| | | L | 22 53 57 | 20 | | | | |
| | | M | 22 57 07 | 20 | 6 | | | |
| | | F | 23 05 32 | | | | | |
| | | P | ?22 44 22 | 6 | | | 2,200 | |
| | | S | ?22 48 02 | 10 | | | | |
| | | L | 22 53 55 | 20 | | | | |
| | | M | 22 54 22 | 20 | | 4 | | |
| 4 | | L | 2 34 57 | 20 | | | | |
| | | M | 2 36 27 | 20 | 6 | | | |
| | | L | 2 35 57 | 20 | | | | |
| | | M | 2 36 42 | 20 | 5 | | | |
| 4 | | S | 12 49 32 | 7 | | | | L−S, 5,500 km. |
| | | L | 12 57 27 | 20 | | | | |
| | | M | 12 59 17 | 20 | 5 | | | |
| | | S | 12 49 37 | 7 | | | | L−S, 5,700 km. |
| | | L | 12 58 02 | 25 | | | | |
| | | M | 12 59 49 | 20 | | 4 | | |

Chart I. Tracks of Centers of Anticyclones, March, 1923. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

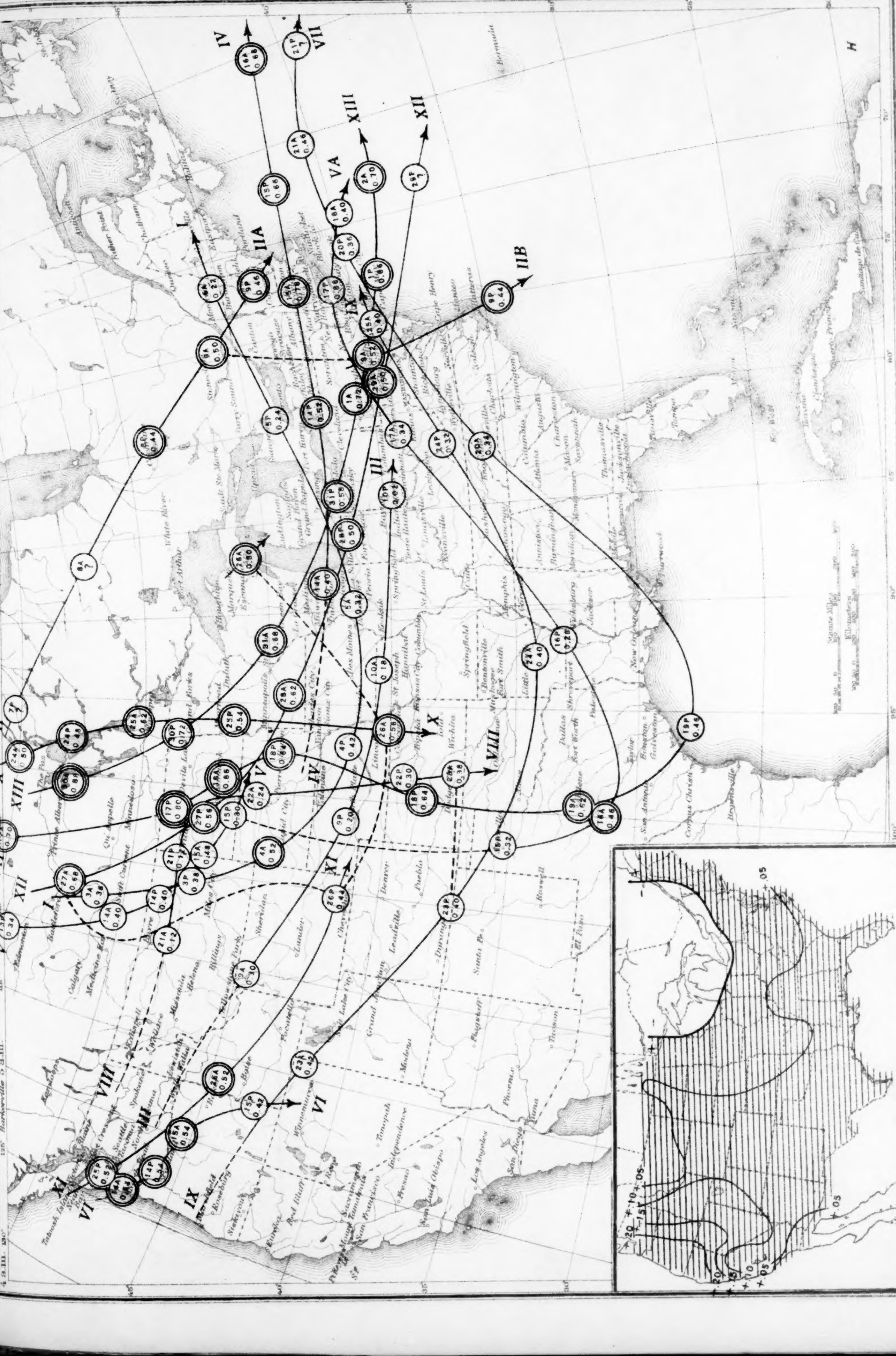

Chart I. Tracks of Centers of Anticyclones, March, 1923. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

Chart II. Tracks of Centers of Cyclones, March, 1923. (Inset) Change in Mean Pressure from Preceding Month.

(Plotted by Wilfred P. Day.)

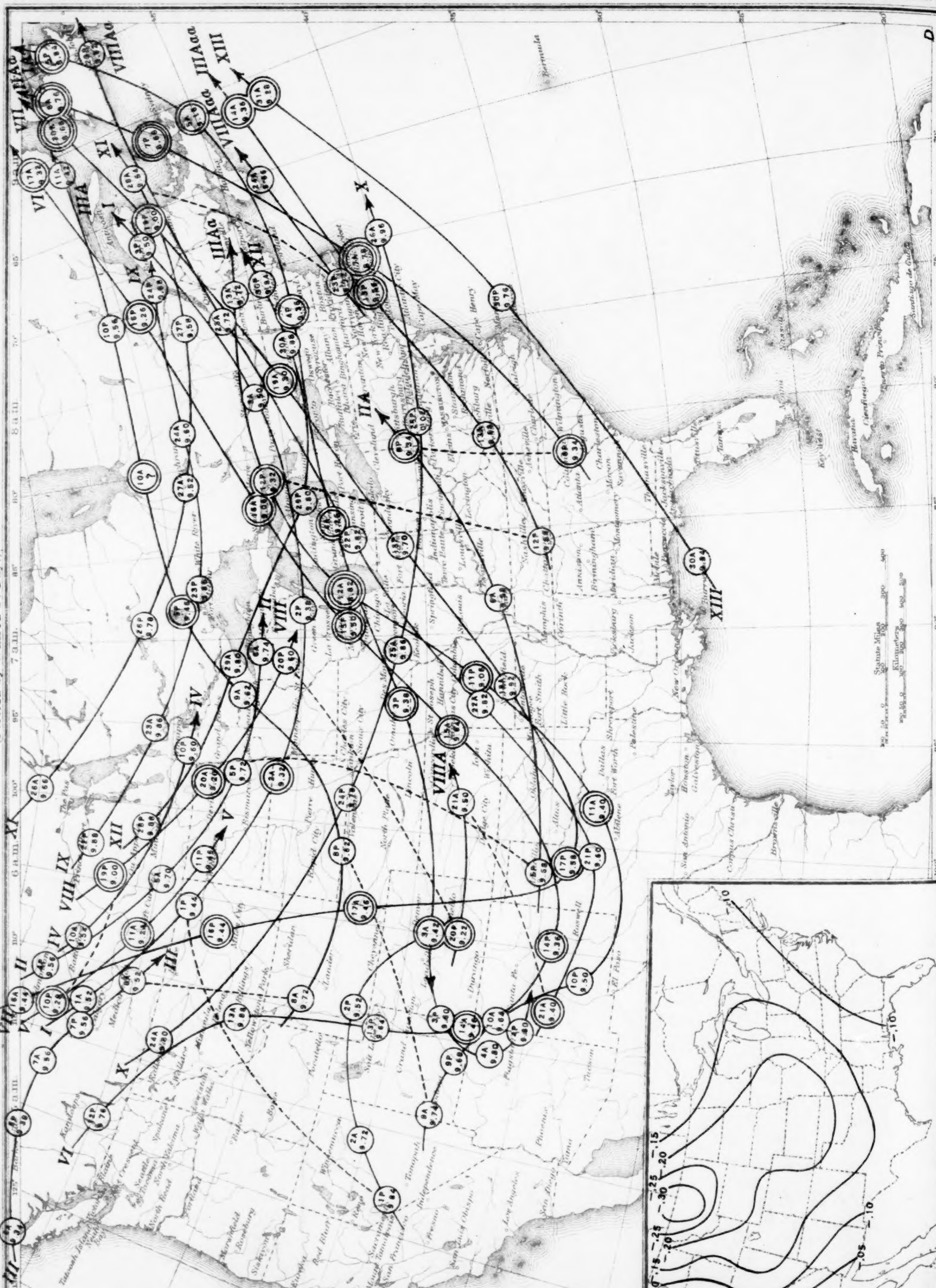

Chart III. Departure (°F.) of the Mean Temperature from the Normal, March, 1923.

Chart III. Departure (°F.) of the Mean Temperature from the Normal, March, 1923.

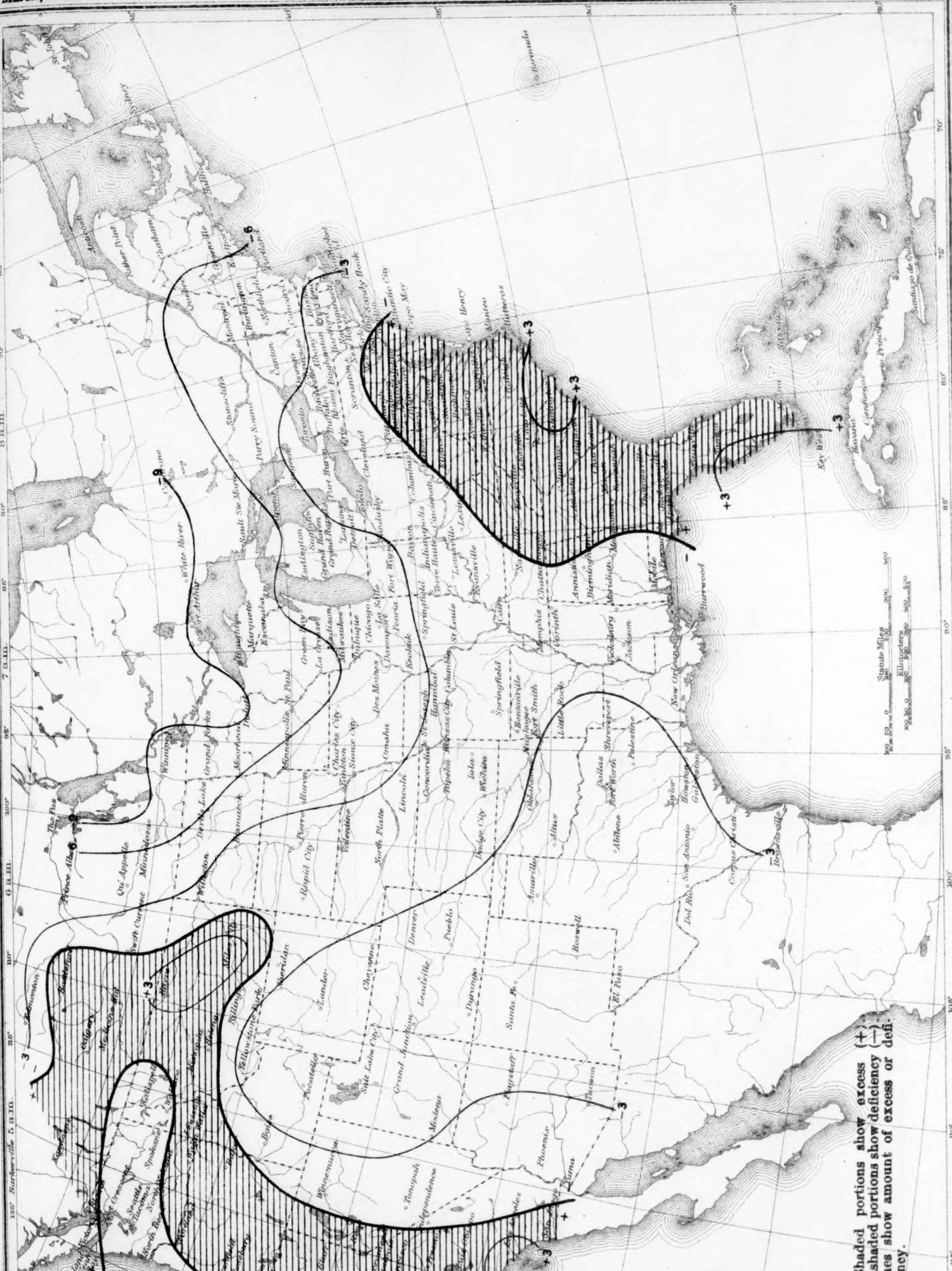

Chart IV. Total Precipitation, Inches, March, 1923. (Inset) Departure of Precipitation from Normal.

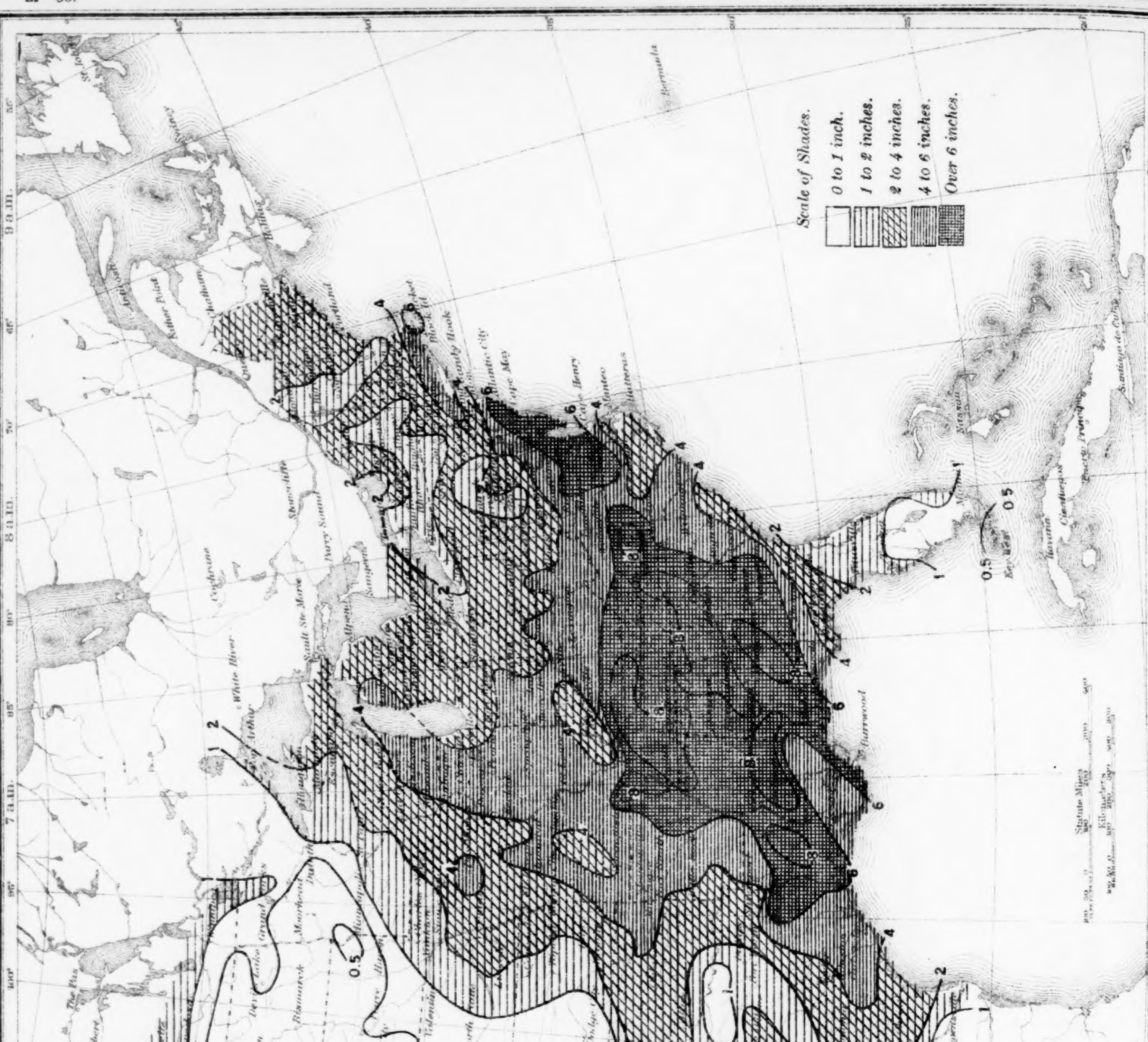

Chart V. Percentage of Clear Sky between Sunrise and Sunset, March, 1923.

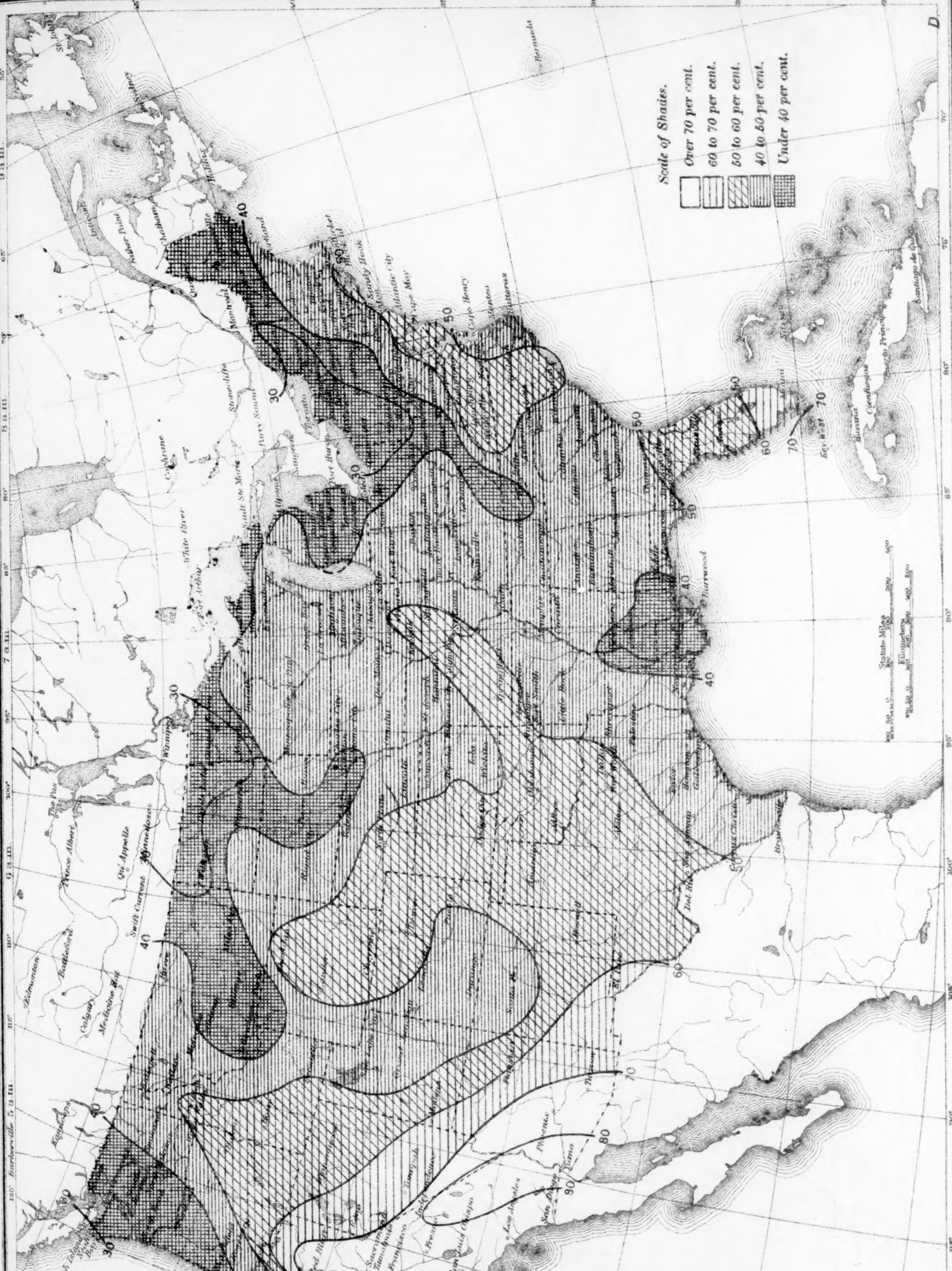

**Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, March, 1923.**

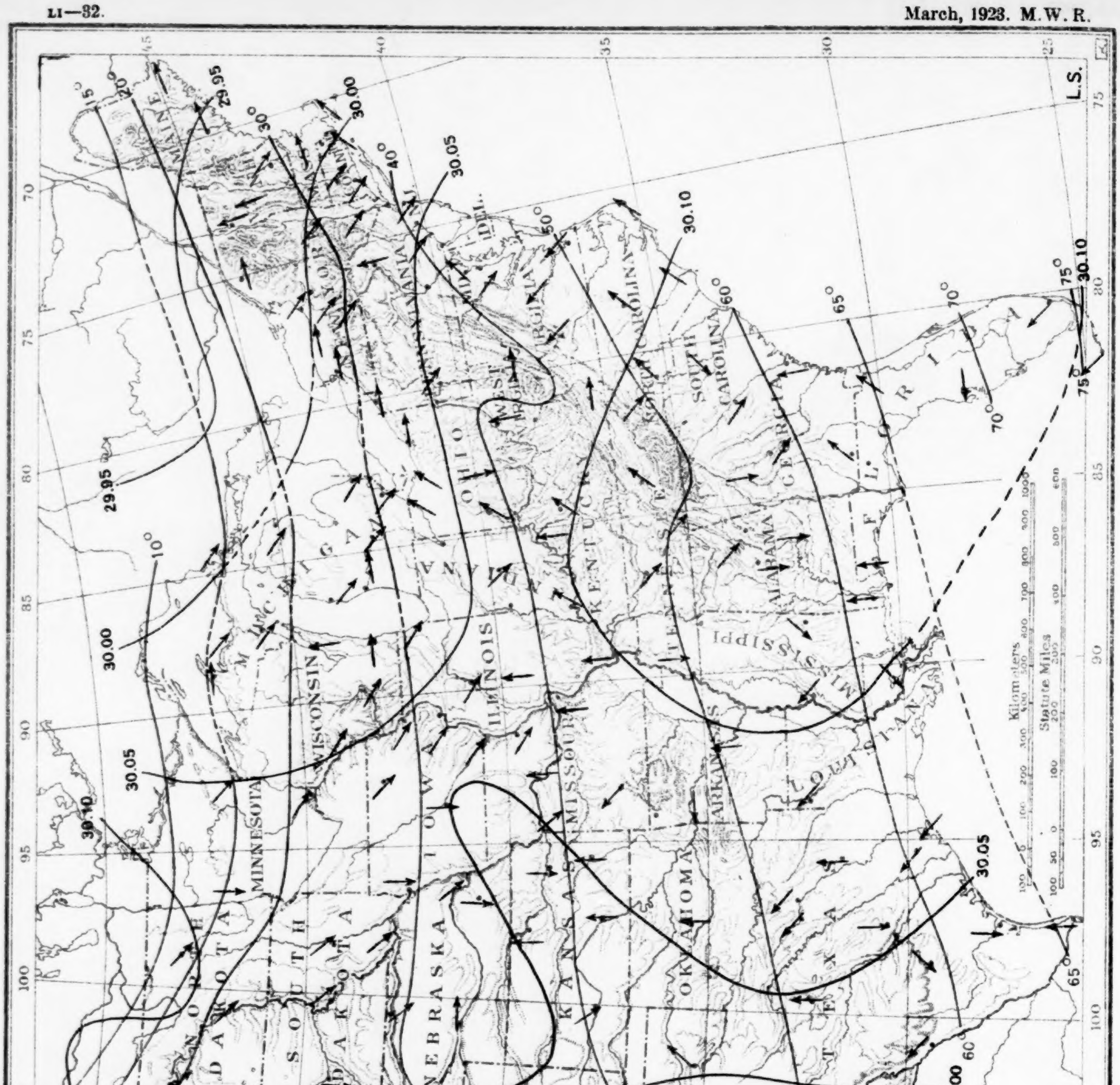


**Chart VII. Total Snowfall, Inches, March, 1923. (Inset) Depth of Snow on Ground at end of Month.**

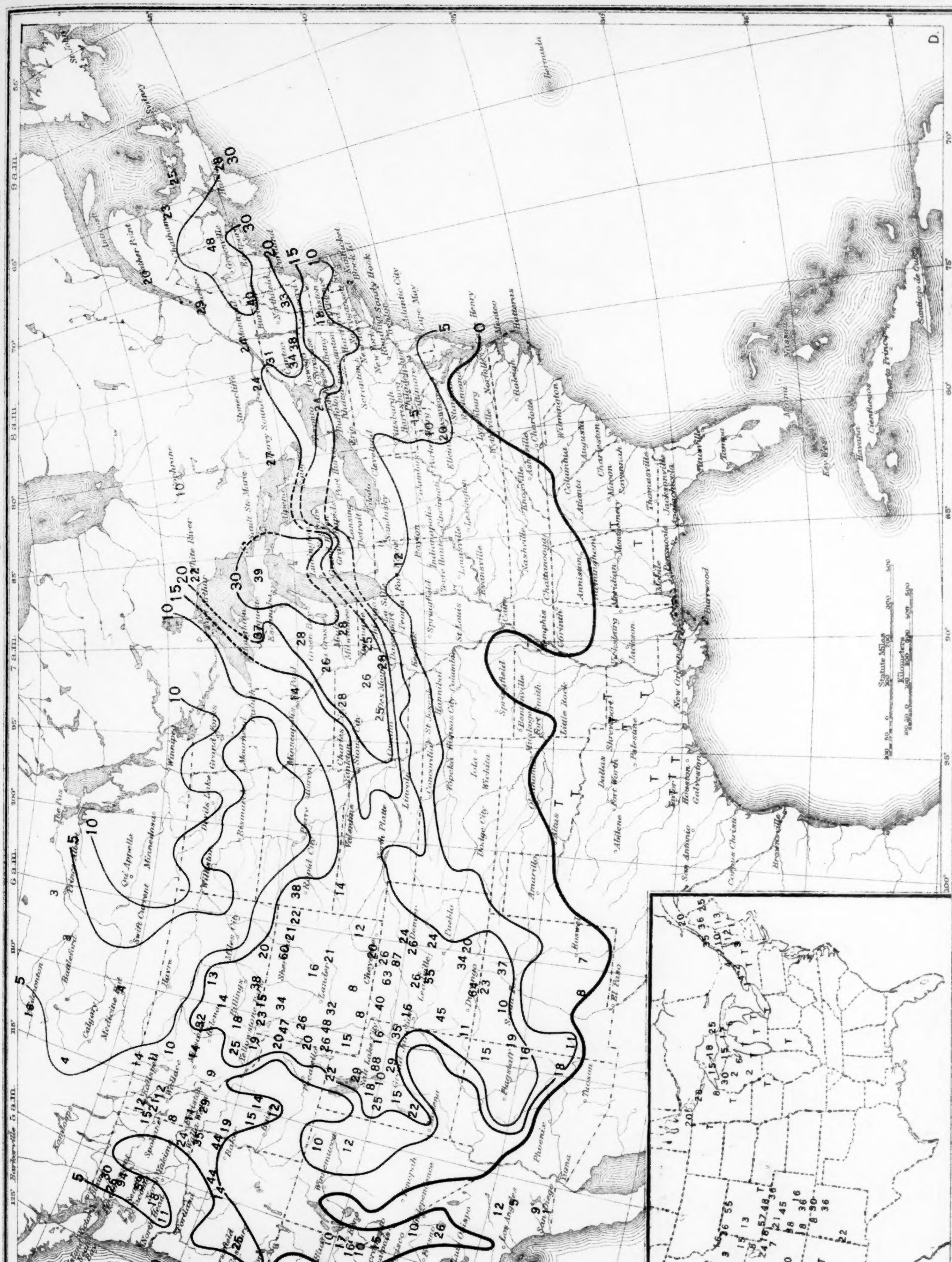

Chart VII. Total Snowfall, Inches, March, 1923. (Inset) Depth of Snow on Ground at end of Month.

Chart VIII. Weather Map of North Atlantic Ocean, March 2, 1923.
(Plotted by F. A. Young.)

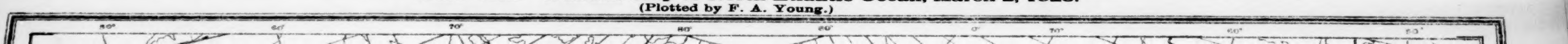

Chart VIII. Weather Map of North Atlantic Ocean, March 2, 1923.
(Plotted by F. A. Young.)

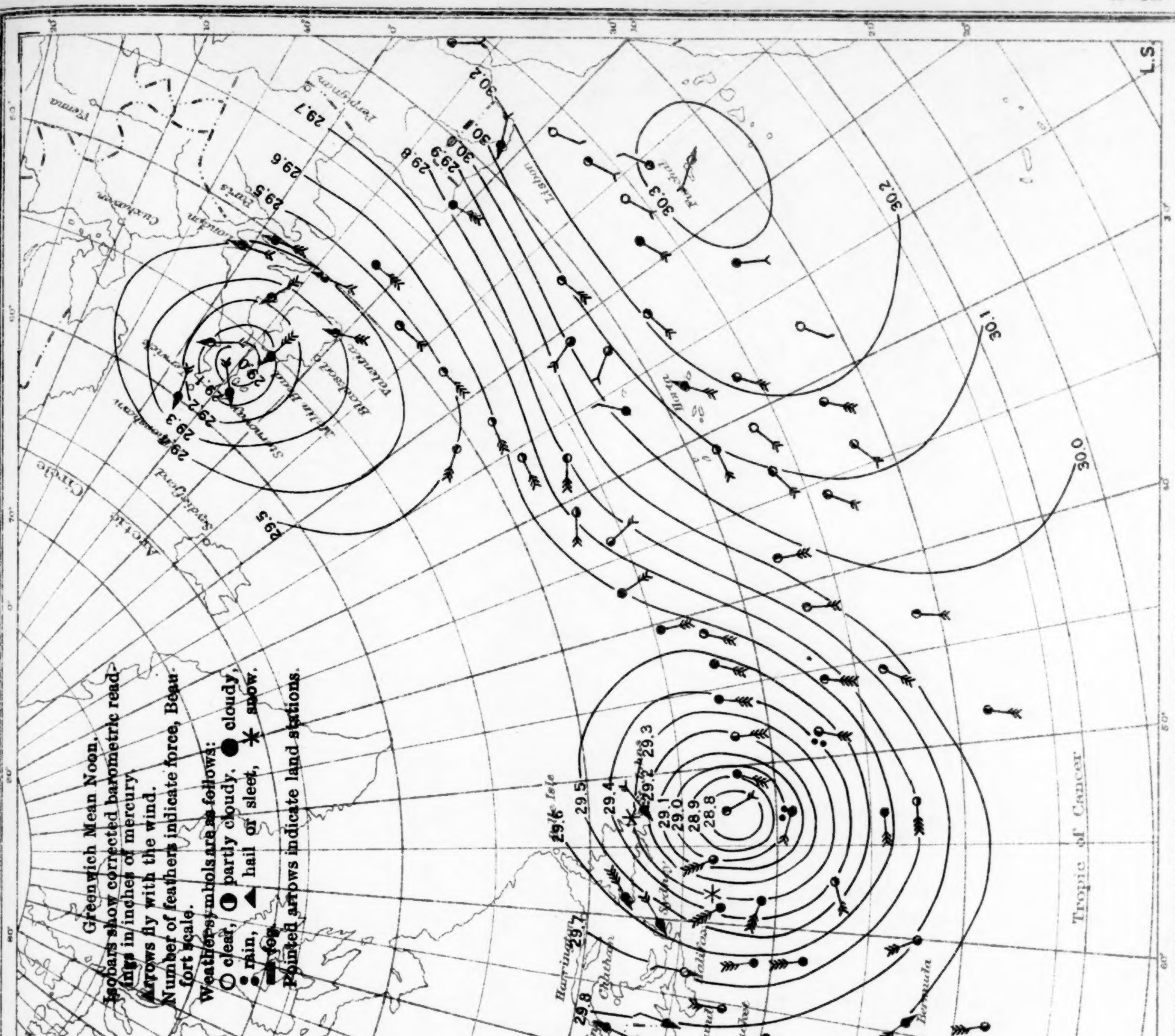

Chart IX. Weather Map of North Atlantic Ocean, March 3, 1923.
(Plotted by F. A. Young.)

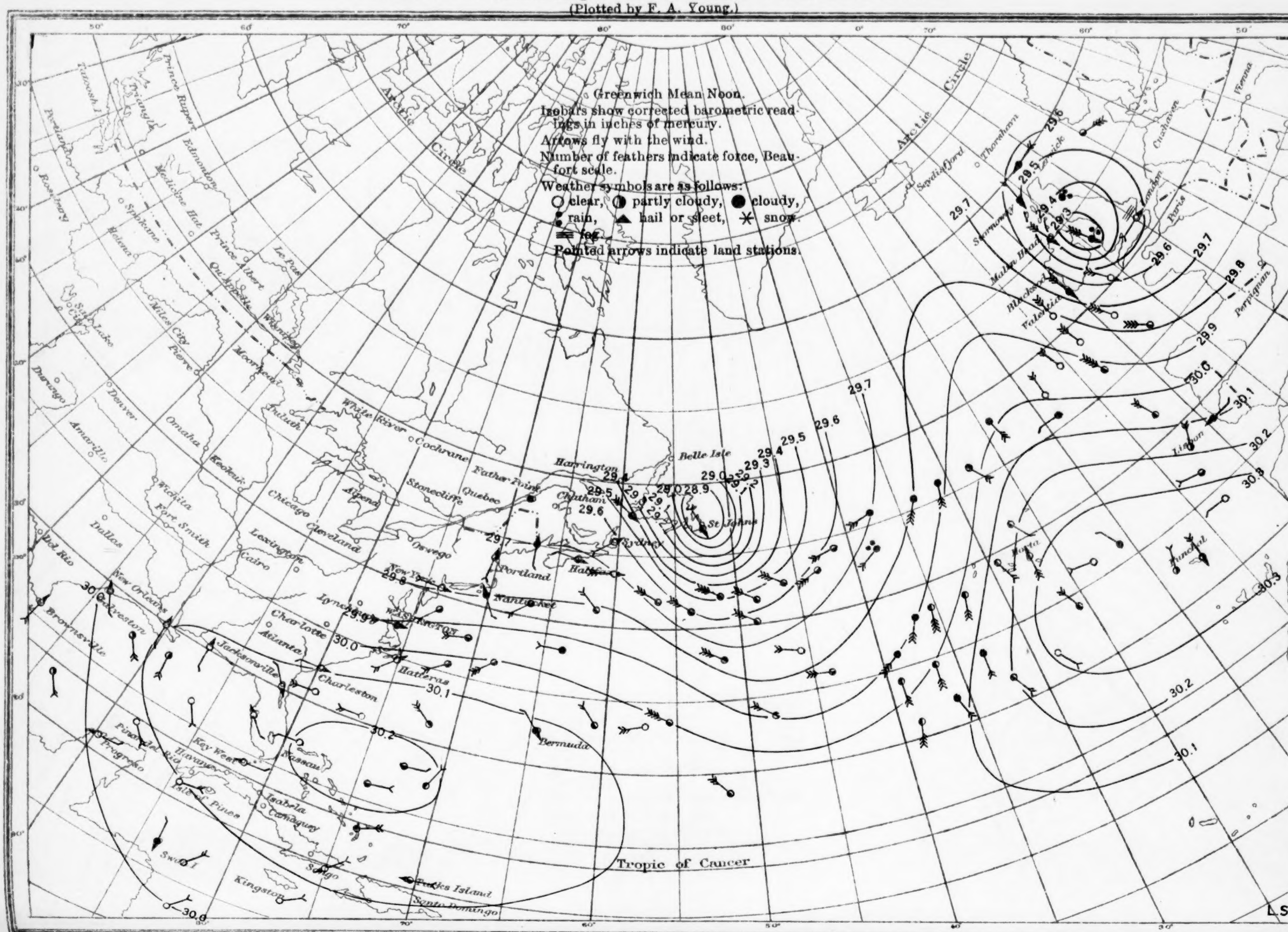


Chart X. Weather Map of North Atlantic Ocean, March 4, 1923.
(Plotted by F. A. Young.)

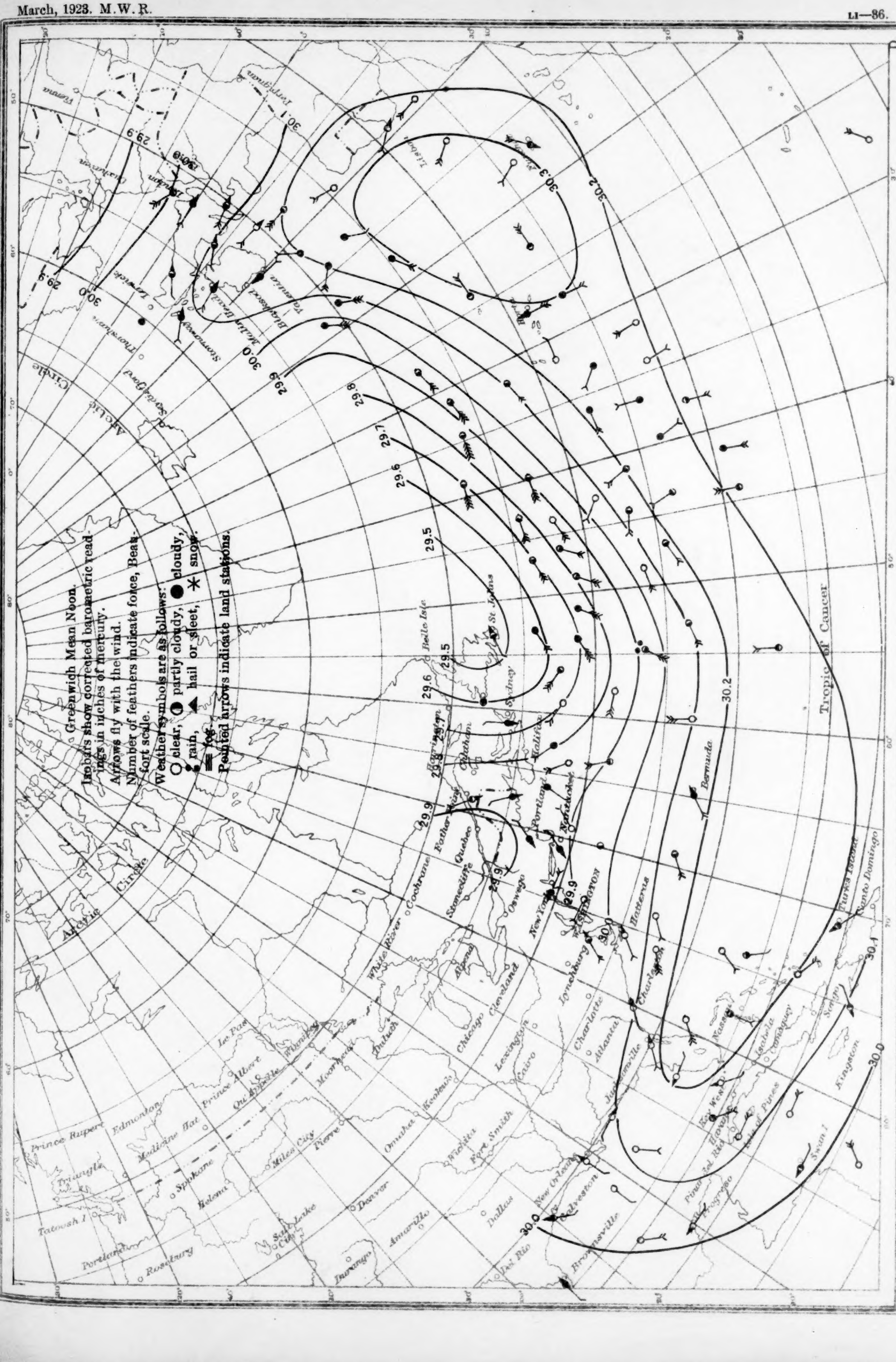


Chart X. Weather Map of North Atlantic Ocean, March 4, 1923.
(Plotted by F. A. Young.)

# Chart XI. Weather Map of North Atlantic Ocean, March 5, 1923.
(Plotted by F. A. Young.)